Journal of ENGINEERING EDUCATION

May, 1961 ***Table of Contents*** **Vol. 51, No. 9**

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Teaching Positions Wanted

POSITION AS A PROFESSOR OF Civil Engineering Wanted. A former professor of Civil Engineering, who for the past four years has been a consultant engineer and research consultant, wants to go back to teaching again. (60 years old.) The research has involved the creep and shrinkage influence on prestressed lightweight concrete girders, long spans, 56–64 feet, and the influence of time on these factors. He wishes to continue this research with private funds now supplied. Author of several textbooks, books and articles. Over 300 beams now erected in various structures are under investigation. Is financially indepent, so salary is of minor importance. Write to 51-10, *Journal of Engineering Education*, University of Illinois, Urbana, Illinois.

M.E.E. WORKING TOWARDS DOCtorate, with 8 years in industry, seeks teaching post from June or September 1961. Write 51-11, *Journal of Engineering Education*, University of Illinois, Urbana, Illinois.

INDUSTRIAL ENGINEER–BSME, MSIE, PE–6 years teaching experience–20 years industry including 15 years Chief Industrial Engineer–Considering return to teaching–Resume on request. Write 51-12, *Journal of Engineering Education*, University of Illinois, Urbana, Illinois.

Do You Know

► That the Annual Meeting is at the University of Kentucky on June 26–30? You have received your copy of the preliminary program and preregistration and housing reservation card. Better send it in promptly if you want to get into the air conditioned dorm!

► That a record attendance of 319 industry and education representatives was set on Feb. 2–3 at the 13th College-Industry Conference of the Relations With Industry Division of the ASEE? Twelve nationally known speakers, including John J. Healy, President of AIChE, and Dr. Eric A. Walker, President of ASEE, discussed the theme topic "Developing and Maintaining a Professional Climate in Engineering." Demonstrating a need for concerted effort in the community, the Conference held sessions at the headquarters of the Engineering Society of Cincinnati, on the campus of the University of Cincinnati, and with the Cincinnati Chapter of the Society for the Advancement of Management. A complete set of the papers presented at the Conference is available through the College of Engineering, University of Cincinnati, at a cost of $5 per copy.

► That the new ASEE-Leeds and Northrup Fellowship has been awarded to the University of Kansas? The institution selects the recipient and the $3,000 award is divided between the recipient and the institution. If the recipient makes satisfactory progress toward the doctorate the Fellowship is renewed for two additional years.

► That "Books for Asian Students" needs scientific and technical engineering books and technical journals in runs of five years or more? University, college, and secondary books in good condition published after 1945 or works by standard authors published before 1945 are wanted. The Asia Foundation, 550 Kearny Street, San Francisco 8, California, will pay transportation costs from the donor to San Francisco and thence to Asia. Books may be shipped by the following methods only: educational materials rate parcel post in packages under 70 pounds (reimbursement for which will be sent on receiving donor's postal receipt); or if quantity is large by motor freight (truck) collect (not Railway Express or moving van). Shipments should be in ordinary cardboard cartons, securely tied, to: "Books for Asian Students, 21 Drumm Street, San Francisco 11, California." All questions concerning categories, criteria, shipping and so forth should be directed to the same address.

► That a monkey could hit upon the Equation $E = MC^2$ in less time than it took Einstein to reach it? So states a news release from the University of Michigan. This is part of an observation of Robert Sommer of the Saskatchewan Hospital in Weyburn, Canada in an article in the "Worm Runner's Digest," an informal journal of the University of Michigan's Department of Psychology's Planaria Research Group. The conclusion reached about the monkey is based on his punching four keys at random over a long period of time. The odds on the monkey hitting the equation on the first try is only 42^4. In pointing out the value of good secretarial help to scientists, Mr. Sommer further states, "If a monkey can do this we should certainly expect more from our stenos, some of whom can type 70 words a minute. Think of the scientific laws that could be produced if four secretaries typed random letters at top speed." Sommers also formulated the following "law" for the scientific output of any research laboratory:

$$\text{Productivity} = \frac{\text{Number of secretaries} \times \text{Average Typing Speed}}{\text{Number of Scientists}}$$

He also states that the laboratory with one scientist and four secretaries is in a more favorable position than the laboratory with four scientists and one secretary.

► That you had better check your watch and yardstick? The length of the

meter now is 1,650,763.73 wavelengths of the orange-red line of krypton 86 instead of the distance between two engraved lines on the International Meter Bar. The length of the second of time is 1/31,556,925.9747 of the tropical year 1900 instead of 1/86,400 part of the mean solar day. Adoptions were made at the 11th General Conference on Weights and Measures which was held in Paris last October.

► That "Experimental Mechanics" is the name of a new monthly publication of the Society for Experimental Stress Analysis? A grant of $45,000 to extend over a period of three years has been awarded SESA by NSF. Previously the society limited its publications to two a year. The first issue came out on January 1, 1961. SESA's address is P.O. Box 168, Cambridge, Mass.

► That 53 colleges of engineering are among the 250 colleges and universities participating in the undergraduate research programs sponsored by NSF? The 39 institutions have a total of 53 programs. About 13% of the total number of undergraduates participating are in engineering; biology is the only area having a greater percentage, 26. Seventeen of the 53 programs are in chemical engineering, 10 are in EE, 7 in ME and 6 in CE. The others are scattered in eight fields, including the general area of "engineering."

► That "The Science Doctorates of 1958 and 59—Their Numbers, Characteristics, and Employment" is a new publication of the National Science Foundation? Through 1959 the number of doctorates in engineering increased 50% (the ASEE–U. S. Office of Education data indicates 45%), whereas the percentage increase in chemistry, physics, mathematics, and geology were 1, 24, 73, and 81 respectively. The average increase for the physical sciences is 26 as compared to increases of 42, 45, and 122 for all sciences, life sciences, and behavioral sciences, respectively. The mean age of the Ph.D. recipients in physical sciences is 30.6 years; 31.8% of the recipients are 27 years of age and under, this percentage being more than twice as many as for the life and behavioral sciences. The mean time lapse between baccalaureate and doctorate degrees for the physical scientists is 7.5 years compared to 8.6 for life scientists and 9.4 years for the behavioral scientists. It also is interesting to note that the per cent of doctorates in the physical and behavioral sciences in general increases with the size of high school graduating class whereas the percentage for the life sciences decreases very significantly. Copies of the report are available from the Supt. of Documents, U. S. Govt. Printing Office, Washington 25, D. C., for 25¢ each.

► That four colleges of engineering have one or more curricula accredited by ECPD this year for the first time? Sincere congratulations are extended to Brigham Young, Miami University, Fairleigh-Dickinson, and Puerto Rico. This brings the number of schools with accredited curricula to 159, and the total number of accredited curricula to 842. The largest number of accredited curricula are in electrical engineering with 143; then comes civil engineering with 141, mechanical engineering with 137, and chemical engineering with 100. Eight institutions have only one curriculum accredited and three schools each have 14 accredited curricula. The 28th Annual Report of ECPD contains the following statements from the Education & Accreditation Committee: "Engineering Education today is dynamic. Increasing emphasis on science, greater depth in engineering analysis, new approaches to synthesis and design, rapid growth in graduate study and in research, curricula in new technologies—all are evidence of the transition and evolution occurring in engineering education. Some current educational innovations are bold, imaginative, and experimental. Beyond this current position is a growing interest in the concept of "Professional Engineering Education," in the sense of medical and legal education taught in a professional school, following basic education in science, mathematics, the liberal arts, and fundamental engineering science. Pressure for accreditation of graduate programs continues to mount. Soon the

present policy of accrediting "First Degrees" whether carrying the B.S. or M.S. designation in a specified curricula will be inadequate to meet the issues raised by schools, professional societies, and industrial sponsors of part-time graduate study programs." To study this last problem ECPD has established an ad hoc study group of E. C. Easton, N. A. Hall, H. L. Hazen, and R. R. White. The Annual Report with its reports of committees and constituent member societies, and lists of accredited curricula, is good reading. Copies are available from ECPD for $1.00 each.

► That the second International Heat Transfer Conference will be held at Boulder, Colorado, August 28 to September 1, 1961? The conference is sponsored by four engineering societies, two American and two British, with participation by eight others from the U. S. and Canada. The University of Colorado is serving as the host institution. Registration information and advanced programs may be obtained by writing to the ASME, Meetings Department, 29 West 39th Street, New York 18, New York.

► That there are two separate and distinct organizations known as the Future Engineers of America? Reference to the one headquartered in Chicago was made in the October issue of the *Journal* in the "Do You Know" column, page 5. The second is an energetic organization whose activities are centered in Southern California. The primary purpose of its program is to provide gifted young people interested in engineering the opportunity to work in well equipped laboratories under the supervision of highly qualified engineers and scientists from industry. The California FEA recently has completed a cooperative agreement with JETS under which it will act as a central distribution and coordinating agency for the dissemination of material supplied by JETS. The President of the California FEA is Mr. G. E. Speen, P.O. Box 2664, Sepulveda, California.

► That the first Scandinavian Research Guide has been published in English? It is a directory of research institutions within technology and science, exclusive of life sciences, designed for persons engaged in the field of science and technology. Concise, detailed, and factual information on over 1500 research institutions in Denmark, Finland, Iceland, Norway, and Sweden are included. This initial effort to provide a complete and reliable picture of present day Scandinavian research is the effort of the Scandinavian Council for Applied Research (SCAR) and is designed to further the cooperation between institutions and persons engaged in scientific and technical research. The two volumes cost $10.00 and are of conventional book size, about 1200 pages. Copies should be ordered from the Scandinavian Council for Applied Research, Gaustadalleen 30, Blindern, Norway.

► That many of you will want to remain in Lexington over Friday of the Annual Meeting to attend some of the meetings of the Agricultural Engineering Division? The highlight will be an address at 11:00 a.m. on Friday by the Honorable Orville L. Freeman, Secretary of Agriculture. The theme of their meeting is "Agricultural Engineering in World Agriculture." Malcolm Jones, Head of the Water Resources and Equipment Branch of the International Cooperation Administration, will speak on "Attitudes, Culture, etc. on Engineering Education in Other Countries." The hot topic of "Educational Needs of Foreign Students in the United States Classroom" will be discussed by Dean J. N. Efferson of the College of Agriculture of Louisiana State University. "Analysis of Engineering Curricula Evaluations" will be the topic of an address by Dr. A. H. Willis, Dean of Engineering, University of New South Wales, Australia. Still another will be "Viewpoints of a Former Student From Abroad" by Dr. N. N. Mohsenin of Penn State University. This is a bangup program and should be of interest to many in addition to those who are Ag Engineers. Plan now to go to the UK and enjoy the blue grass country for a week starting June 26—and take your family!

W. LEIGHTON COLLINS
Secretary

The Question of Establishing a National Academy of Engineering

HAROLD K. WORK

Director,
Engineering Foundation
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Associate Dean, College of Engineering
New York University

The proper solution to the question of establishing a National Academy of Engineering is important to the nation, the engineering profession, and ASEE. This article is published to stimulate discussion and assist in gathering a consensus. I will appreciate the opinions of members of ASEE. Send them to me at The Pennsylvania State University, University Park, Pennsylvania. The subject will be discussed at the meeting of institutional representatives of ECAC on Thursday morning of the Annual Meeting at the University of Kentucky, June 29, 1961.

ERIC A. WALKER
President, ASEE

Several months ago there was a brief note in *Science* to the effect that J. Herbert Hollomon, General Manager of General Engineering Laboratory of General Electric Company, recommended that a National Academy of Engineering be established. After discussion with him a request was made to the Research Procedures Committee and the Executive Committee of the Engineering Foundation for permission to study Dr. Hollomon's suggestion further. Permission was granted but there was strong underlying feeling in the Executive Committee that Engineers Joint Council should be involved. This was mentioned to Dr. Kinzel and a meeting with Dr. Gaudin, Chairman of the Foundation, and Dr. Kinzel resulted. At this time steps were initiated to explore the matter further.

The concept of establishing a National Academy of Engineering is not new; it has been suggested several times. In fact, when the National Academy of Science was founded it was probably intended that engineering should play a larger part in the operation of the Academy than it actually has. In a release last April announcing the election of 35 new members (including Dr. Kinzel, Chairman of EJC) the following statement was made:

"Washington, April 26—The National Academy of Sciences announced today the election of 35 new members on the basis of their distinguished and continued achievements in original research. Their election took place this morning at the 97th Annual Meeting of the Academy at its headquarters here. Election to membership in the Academy is considered to be one of the highest honors which can be visited upon an American Scientist.

The National Academy of Sciences is a private organization of over 580 distinguished scientists, dedicated to the furtherance of science and to its use for the general welfare. The Academy was established in 1863 under a Congressional Charter signed by President Lincoln. Empowered to provide for all activities appropriate to academies of science, it is also required by its Charter to act as an adviser to the Federal Government in scientific matters. This provision accounts for the close ties that have always existed between the Academy and the Government, although the Academy is not a governmental agency."

The phrases in this news release are particularly pertinent to this discussion:

1. The new members were selected on the basis of their distinguished and continuing achievements in original research.

Presented before Engineers Joint Council, September 9, 1960.

2. The Academy is dedicated to the furtherance of science and its use for the general welfare.
3. It acts as advisor to the Federal Government.

There seems to be a discrepancy here. The membership is predominately composed of research scientists. A check of the records will show only a small per cent of engineers among the members, yet the use of science for the general welfare sounds more like engineering. It becomes increasingly obvious that the National Academy of Sciences is primarily oriented toward science even though its affiliate, the National Research Council, does have extensive engineering activities. The question can now be raised as to whether or not the formation of a National Academy of Engineering would assist the engineering profession in carrying out its obligations to society.

In order to answer it would help to have some concept as to what the Academy might be like. This includes objectives, organization, method of operation, etc.

As objectives the following are presented for consideration:

1. Render a national service which is not being rendered now.
2. Develop a clearer understanding of the attributes of an engineer.
3. Raise the standards of the engineering profession so that the profession may better serve mankind.
4. Honor a substantial group of outstanding engineers.

An obvious question can be immediately raised; namely, could the National Academy of Sciences be alerted to take care of the needs of the engineering profession? If so, that should be given serious consideration. If, on the other hand, a separate Academy is required, every effort should be made to see that such an Academy cooperates closely with the National Academy of Sciences so as to best serve the national interest.

It is interesting to note that such a dual Academy arrangement exists in Sweden. There, the older Academy is involved in distributing the Nobel prizes in Physics and Chemistry and has a distinctly pure science flavor. The newer Academy is largely directed at engineering, and its divisions reflect this, for they are almost all engineering in character.

Should a decision be made that an Academy of Engineers is needed, a whole new series of decisions will then have to be made.

1. How should the Academy be initiated?
2. Should it be autonomous and self-perpetuating or should it be allied to existing engineering organizations?
3. Is a Congressional Charter necessary and desirable?
4. How large should the Academy be and should it be initiated at full strength or is a period of growth desirable?
5. What should be the criteria for election to the Academy?
6. How should the Academy be subdivided? Should this be along conventional engineering groupings? Should some of the newer interdisciplinary groupings be used, such as power, materials, communication? Should some other divisions, such as production, design, management, research, and teaching, be used?
7. How should the Academy be financed?
8. The housing of the Academy presents problems. Should it be located in Washington or New York? If in Washington, should an attempt be made to find an imposing or modest home? Is such a home necessary immediately or can this wait until the Academy is well under way?

This gives a sample of the problems that face us in deciding whether or not to form a National Academy of Engineering and how to do it.

Coming back to the question of whether or not an Academy should be established, this depends to some extent on how each individual regards the current status of the engineering profession. There seems to be a wide spectrum of opinion on this point. At the one extreme is the engineer who is completely

satisfied with everything about the profession. At the other extreme we have those who view with alarm the future of the profession—who feel that if present trends continue the engineer will soon join the horse and buggy. In between these two extremes are many thoughtful engineers who, while proud of the past record of the profession, are concerned as to whether or not the engineer has evolved sufficiently to meet his obligations in the nuclear and space age.

The reason for the wide spread in the thinking about the current status of engineering is, it is believed, in no small degree a matter of timing, or where the effect appears first. At the universities, for example, there is much concern over the trend away from engineering toward science. The same situation seems to be developing in medicine as was mentioned in the *New York Times* a few weeks ago. The trend appears more deep-seated than the usual variations in popularity of one profession with respect to another. Concern over this trend has not, as yet, extended very far outside of the universities, but that is to be expected since the effect is immediate in the universities and more remote for those outside.

There must be a reason for the trend. It is suggested that one of the factors is the determined effort to advance the cause of pure science. Huge sums of money from the National Science Foundation and a concerted effort by the country as a whole to advance American basic science have resulted in a skillful and highly successful campaign.

The question is now raised as to whether or not the over-correcting of the past deficiencies of American basic science has affected the applied sciences of engineering and medicine. Now I am sure that there will be some that will challenge this point of view; who will contend that pure science is good and there can never be too much of it. This I do not agree with.

Some years back, Dean Hollister pointed out at an Engineering Manpower Commission meeting why it was so difficult to increase the supply of engineers. He showed that the number of people in the total population with the intellect to be professional people, lawyers, doctors, engineers, and the like, is small. Any attempt to increase one group will generally be accomplished at the expense of the others. It is my impression that this balance has been disturbed.

We must then face the question as to whether this is bad or good. Without going into detail it is my contention that we need the surgeon, the engineer and other applied scientists who have been trained to attack specific projects against deadlines within economic limits. This in no way detracts from the pure scientist who shuns specific objectives, deadlines, and cost in order to achieve his objectives. But we need both in proper proportion.

If the premise is agreed to that the engineering profession and the good of mankind can be harmed if things are out of balance, then steps should be taken to correct the situation. The formation of a National Academy of Engineering might contribute to this, but it must be recognized that this is merely one step of several that are required to solve the problems facing the profession.

The study that Engineers Joint Council is proposing to determine the desirability of establishing a National Academy of Engineering is particularly appropriate at this time.

LACEY DEAN AT CALTECH

The appointment of Dr. William N. Lacey as Dean of the Faculty at the California Institute of Technology has been announced by President L. A. DuBridge.

Dr. Lacey, who assumed his new duties February 1, is a distinguished chemical engineer. He served as Dean of Graduate Studies at Caltech from 1946 to 1956 and has been a member of the faculty for 45 years. In his new post he succeeds Dr. George W. Beadle, who recently accepted the Chancellorship of the University of Chicago. Dr. Lacey has been a member of ASEE since 1957.

For the Whole Family

The ASEE Annual Meeting at Kentucky

A busy and interesting week is in store for women and children attending the annual ASEE meeting at the University of Kentucky June 25–30.

Committees have been working for months planning events and activities designed to insure an "unforgettable" week for families of ASEE members. The preliminary convention program carries a detailed account of these activities. Here are a few of the highlights:

For Women

Women's headquarters will be in air-conditioned Haggin Hall where there will be an information desk, bridge tables, writing tables and supplies, bulletin boards, lists of baby sitters, etc. Morning coffee will be served here each day from 9 a.m. to 10:30 a.m.

First day activities for women will include a leisurely walking tour of the University campus and its many interesting places, including the Carnegie Museum of Anthropology, atomic fallout shelter in the President's home and the Rees Doll Collection at the Home Economics Building. A special luncheon will be held for young engineering teachers' wives and a welcoming tea is scheduled for the first afternoon at the home of Dean and Mrs. R. E. Shaver. An 8 p.m. "mixer" at the Student Union Ballroom will climax the first day's activities.

Scheduled the remainder of the week in a manner so that women may take advantage of all our tours of famous horse farms in the Lexington area, tours of many famous homes, including Spindletop Mansion owned by the University; luncheons, style show, evening steak fry, trip to Berea College and luncheon at Boone Tavern; trip to Harrodsburg and Danville with ample time to browse in museums and antique shops; modern art exhibition and lecture; and, with their husbands, the annual banquet on Thursday evening.

For Teenagers

For teenagers, there is also a week of activities. Included are a get-acquainted party, swimming party at Lansdowne Country Club, sock hops with professional disc jockeys and master of ceremonies, tour of horse farms, all-day trip to Natural Bridge State Park, tour of Spindletop Mansion, party, swimming, games, lunch, dinner and dance at Carnahan House and other campus activities. The Memorial Coliseum swimming pool will be open each afternoon and there will be games, records and dancing available at all times in Bowman Hall, Teen Headquarters for the ASEE meeting.

For the Children

Headquarters for grade school children will be at Taylor Education Building gymnasium where each day there will be sports, games and crafts, lunches, square and folk dancing, etc. The youngsters during the week will see a magic show, take a trip to the Bird and Animal Forest, tour the UK zoology and anthropology museums, and see the UK dairy and dairy farm.

A professionally staffed nursery school and kindergarten will be available for smaller children in the Taylor Education Building from 9 a.m. to 4:30 p.m. each day.

Registration fees for all ages, except those 3–6, are $1 for each person. Prices for the various trips, tours and meals vary and are levied only to defray actual costs of the events.

For the Men

Besides the usual whirl of Annual Meeting events, the men will find some interesting places to go and things to see, too. One of these is the Kentucky Research Foundation.

The Kentucky Research Foundation during its 15 years of existence and steady growth has enabled the University

of Kentucky to more fully meet its obligations of service to the people of the state.

A corporation, the Foundation acts as agent of the University in solicitation and administration of funds for a variety of purposes: research, public service, scholarships and fellowships, publications, endowment of professorships, provision of new buildings and equipment, and any other purposes consistent with the University's governing regulations and policies.

The Foundation began in 1945 with general fund assets of only $1,929, just two endowments, and no contracts, grants or special projects. Since that time, KRF has managed 176 separate projects involving total appropriations of $3,242,830. Its general fund assets on June 30, 1960, were $1,756,367, an increase of more than $500,000 over the previous year. There have been 1,012 scholarship and fellowship awards administered through the Foundation with the average monthly payroll having grown to more than $21,000. The latter represented a 30 per cent increase over the previous year.

During the 1959–60 academic year, there were 85 University of Kentucky graduate students doing important research work and receiving financial assistance through the Foundation.

Five graduate fellowships ranging from stipends of $2,400 annually to $1,500 annually were provided during 1959–60. During the same period, the Foundation administered 94 different projects distributed among 35 departments and colleges of the University.

Besides its management of earmarked funds, the KRF also manages a number of restricted and endowment funds in support of scholarships, fellowships, lectures, and other educational activities at the University. During 1960, these amounted to 66 restricted funds and 10 endowment funds, from which were assigned 166 scholarships and fellowships.

Five patents have been granted the KRF during its lifetime. Many other inventions arising from research conducted in University laboratories have been considered for patenting by the Foundation.

A sample of the internal service rendered is the 138 research proposals prepared in 34 departments with help of KRF during 1960.

HOUSE THAT RUPP BUILT—Memorial Coliseum is home of world-famous Kentucky Wildcats basketball team and head coach Adolph Rupp. Central Kentucky Concert Association also holds its annual programs here. The Coliseum's swimming pool will be open every afternoon during the Annual Meeting for use by ASEE families.

Annual research conferences involving out-of-town and local personnel are held on the campus under KRF sponsorship.

Another significant part of KRF work is administration of many facets of ICA foreign contracts which the University has with Indonesia and Guatemala. The executive director of the Foundation, Dr. Merl Baker, serves as coordinator for the programs. Total expenditures for the programs through June, 1960, were $2,831,689. UK has 32 persons assigned to the programs.

KRF played a significant role in recommending the establishment of the Kentucky Spindletop Research Center and the Institute which will be a part of a 425-acre research complex on Spindletop Farm near Lexington. The Foundation will continue to help with its development in seeking funds from industries, agencies of the Federal Government, societies, associations and other foundations.

During the last fiscal year, 36 publications resulted entirely or in part from work on contracts held by the Foundation.

Membership of the Foundation includes all members of the Board of Trustees of the University of Kentucky and all members of the Board of Directors of the Foundation itself. It may include in addition a maximum of 30 persons, elected to membership by the Board of

KENTUCKY LIFE MUSEUM—Waveland houses Kentucky Life Museum where is preserved much of the state's history. Slave quarters behind building will be made into reconstructed early Kentucky village.

Directors. These 30 or such lesser number as may be named are classified as national councilors, alumni members, industrial councilors and research members.

Officers are Dr. Leo M. Chamberlain, president; Dr. Ernest N. Fergus, vice president; Dr. Merl Baker, executive director and secretary; and Dr. Frank D. Peterson, treasurer.

For the Whole Family

Texas oil fields made possible the million-dollar setting for a portion of the activities scheduled for the annual ASEE meeting in June at the University of Kentucky.

Perhaps no university in the south has available a more luxurious piece of property than Spindletop—a 40-room mansion surrounded by more than 1,000 acres of famed Blue Grass land.

ASEE visitors will have an opportunity to see and tour the architecturally beautiful and once lavishly appointed home of Texas oil millionaire Miles Frank Yount. The farm was named for Mr. Yount's Spindletop oil field.

The University in 1959 was able to acquire from Mrs. Pansy Yount Grant, the millionaire's widow, Spindletop (Mansion and 1,066 acres of land) for the "gift" purchase price of $850,000. Shortly before the purchase the property had been appraised at twice that amount. The mansion itself, completed in 1935, cost $1,000,000 to build. Part of the farm-425 acres—will be used as a site for the Kentucky Spindletop Research Center, now under development. The mansion is 238 by 60 feet and has three stories and a basement that includes a ballroom, barber shop, kitchen, butler's pantry and game room. First floor space now used by the University for conferences includes a library, drawing room, music room and dining room.

Famous Spindletop Mansion, which cost a million dollars to build in 1935, is now owned by the University of Kentucky and utilized for special meetings and conferences. ASEE visitors to Lexington in June will be able to see the 40-room house and 1,066-acre horse farm where it is situated.

The mansion exudes richness from every room. Some points of interest include:

Two sets of bronze doors costing $14,000; a $55,000 electric organ that can be remotely operated from six stations in the house; several rare rugs (Mrs. Yount presented the University with a 16th century tapestry valued at $100,000); a basement "saddle lounge" decorated in the red and blue colors of the former Spindletop racing stable; a 30 by 60 foot Elizabethan living room; a ballroom under a ceiling of midnight blue sprinkled with stars; Kentucky tap room authentically appointed; ladies powder room with Oriental motif and another in French; linen room containing 32 drawers and 23 closets; and a dog room 22 by 30 feet, tiled, with bathing facilities and wooden fire-plugs.

Outside are a carriage house containing 30 or more horse drawn vehicles; a six-car garage complete with grease rack and chauffeur's tack room, plus two and three-room servants' suites; two lakes, a 40 by 70-foot swimming pool; tennis court, and "pleasure horse" barn.

Around it all—seven miles of chain link fence eight feet high estimated to cost $137,000 during depression years when all builders got a lot for their money.

ASEE visitors will get a lot for their money as they sip tea and stroll through this fabulous part of the University of Kentucky.

DESIGN CONFERENCE AT THE ANNUAL MEETING

At the Annual Meeting next June, ASEE's Graduate Studies Division will hold an open conference on the subject of Design in Engineering Education. At this informal conference, representation from the institutions with Ford Foundation-sponsored studies relating to design will be available to answer questions and to stimulate discussion. There will be no prepared program, and all those interested are welcome to attend and participate.

Opportunity will be provided in this open-house discussion for a maximum of informal exchange of views by individuals who are interested in the development of design objectives in the changing pattern of engineering education. What is design? What are the needs for design emphasis? How can it be taught and at what levels? What degrees are appropriate recognition for design emphasis? Design project vs. research theses. Financing design projects. Individual vs. group efforts. These questions and topics together with others pertinent to the subject of design will be open for discussion. The generation of ideas on design through a maximum of expression of viewpoints forms the basic objective of this informal discussion session which will be centered around audience participation. The discussion period is scheduled for Wednesday afternoon, June 28.

Fifteen Years' Experience with a Five-Year Engineering Curriculum

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This title was chosen to stress the fact that the 5-year curriculum is no longer new. A 5-year engineering curriculum was adopted at Ohio State University in 1945 and became effective that autumn for new freshman students. In the next few years, students returning from military service with prior college credit in engineering had the choice of continuing on the 4-year curriculum or of electing the 5-year curriculum. Some chose the 5-year curriculum. Accordingly, Ohio State has had graduates from this program for somewhat more than 10 years; and the engineering faculty has had 15 years' experience in working with a 5-year curriculum.

Several other schools in the country adopted a 5-year curriculum more than a decade ago, including the University of Minnesota, Cornell, Rice, and the University of Louisville. Many schools have had 3–2 arrangements with liberal arts colleges for years.

This discussion is intended to provide some comparisons of the 5-year curricula with some 4-year curricula, drawing primarily from the experiences at The Ohio State University.

In the present era when critical analyses and reshaping of engineering curricula are in vogue, it is interesting to note a continuing interest in the 5-year curriculum. Comments, published in *Civil Engineering* within the past year, concerning studies of engineering education promoted by the ASCE Task Committee on Professional Education indicate a considerable interest in 5-year engineering curricula.

Presented at the Michigan Section Annual Meeting of the American Society for Engineering Education, April 23, 1960.

Enrollment Trends

As soon as the words "5-year curriculum" are mentioned, many faculty and administrators are rightly concerned about one vital factor—how does it affect enrollment? Figures 1, 2, and 3 show enrollment trends in engineering over the past 10 years based on data published in the Yearbook issue of the JOURNAL OF ENGINEERING EDUCATION. The first figure compares total engineering enrollment at Ohio State and at the University of Minnesota, two schools with 5-year engineering curricula, with total enrollment in the engineering colleges at the other Big Ten schools having 4-year curricula, and with the total engineering enrollment in the United States in ECPD-accredited schools. The trends in total engineering enrollment at Ohio State and at Minnesota have been almost identical with those in the other Big Ten schools and in the nation. Comparisons with the other schools having 5-year curricula are not made since it seems to have been their policy to limit enrollment to an approximately constant level; hence they do not follow the national enrollment trends.

The next figure presents the same comparison except that it is based on the number of bachelor's degrees granted in the past 10 years. Again Ohio State and Minnesota follow both the national trend and the trend in the other Big Ten schools. In fact, except for a phase lag of 1 year, the curve indicating the number of graduates at Ohio State has followed almost exactly the curve for first degrees awarded in the nation and by other Big Ten schools.

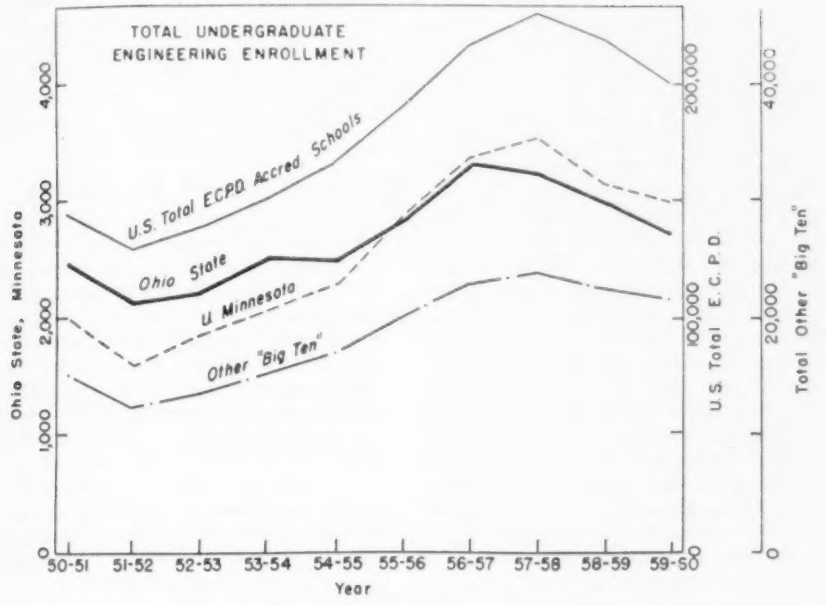


FIG. 1. Total undergraduate engineering enrollment by year.

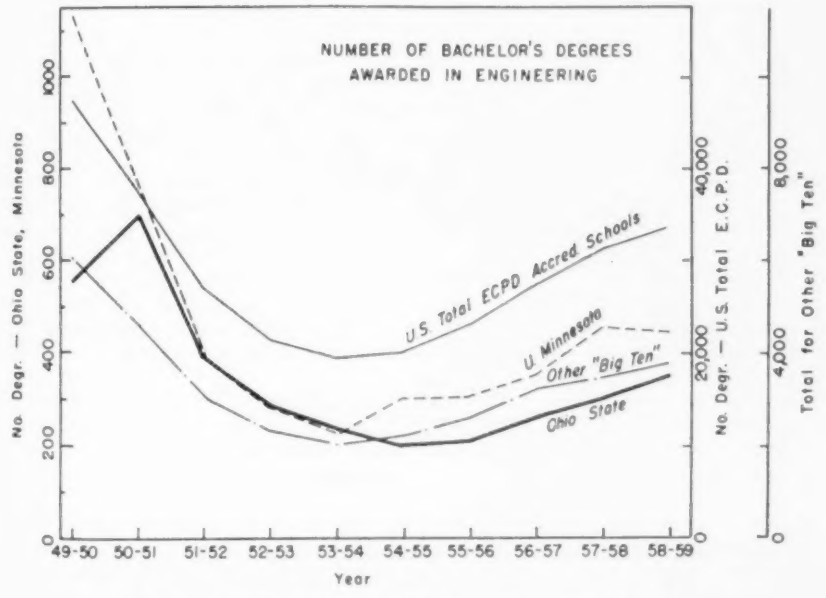


FIG. 2. Number of Bachelor's degrees awarded by year.

Figure 3 presents a comparison of engineering freshman enrollment. Here again, the trends for the 5-year schools have been approximately the same as those for the 4-year Big Ten schools and for the nation as a whole. Some additional factors have influenced the shape of the freshman enrollment curve at Ohio State in recent years. Starting about 3 years ago, the College of Engineering began to enforce the entrance requirements rigorously. Students who did not meet the entrance requirements in physics and mathematics could not enroll in the College of Engineering with deficiencies. Many enrolled in the College of Arts and Sciences until they completed their entrance requirements for engineering. Also, Ohio State started 3 branch campus operations in the past 3 years, which had larger freshman engineering enrollments 2 years ago than in 1959–60. Actually, the number of regular, full-time, beginning autumn-quarter freshmen in engineering at Ohio State has remained nearly constant for the past 2 years; the number decreased 1% in 1958–59 from the previous year and less than 1% in autumn 1959 from last year, which is less of a decrease than that for the nation as a whole. The Big Ten schools having 4-year curricula have experienced a considerable increase in freshman enrollment this past year. This increase results principally from large enrollment increases in 2 schools.

Evaluating Demand for Graduates

Anyone attempting to evaluate curricula soon realizes that we have no good quantitative measure of the quality of our end product—the engineering graduate. Certainly, teachers would be quick to agree that annual income is not a true and valid measure of a man's contribution to society. And, it seems, neither are the numbers of publications or patents produced, value of estate accumulated, number of important industry or government positions held, or civic organizations served—as important as these criteria may be. Hence, we find it most difficult, if not impossible, to evaluate accurately a curriculum on the basis of the performance of its graduates within 10 years following commencement. The Ohio State University has had many graduates of the past 11 years who

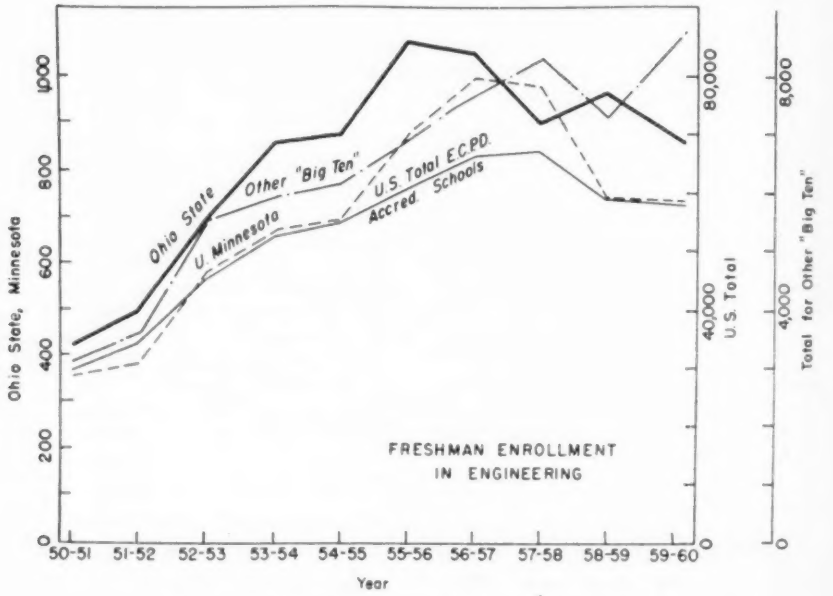


FIG. 3. Freshman enrollment in engineering by year.

TABLE 1

COMPARISON OF STARTING SALARIES FOR GRADUATES FROM 4- AND 5-YEAR SCHOOLS
(Starting Salaries—$ per Month—Engineers with Bachelor's Degrees)

Yr.	O.S.U.	National Ave.			Other 5 Yr.*	Ave. 4 Yr. Schools†	
		Endicott	MCPA	F. Mut.	Range	Range	Ave.
'57	499	454	436		489–493	460–481	469
'58	525	468	469	476	502–508	465–490	479
'59	526	480	490	486	525–530	500–516	509
'60	550			506	545–549	520–535	527

* Cornell, Minnesota.
† Carnegie, Case, Illinois, Michigan, Michigan State, Pittsburgh, Purdue.

rapidly have become eminently successful in their fields. But this is also true for many schools, and I fear it would be misleading to try to compare curricula on this basis.

Some interesting information which can be presented, for what value it may have, is a comparison of the starting salaries for bachelor's degree graduates from 4-year and from 5-year schools. Table 1 presents such a comparison for 10 schools. These data were obtained directly from college placement directors at the schools represented and from 3 nationally recognized salary surveys. The 1960 data are on a predicted basis, but by April the averages are reasonably well established. Figures are presented for Ohio State University and for 2 other universities having 5-year engineering curricula—Cornell and the University of Minnesota. The seven 4-year schools selected for comparison are in the same geographic area as the 5-year schools. The only reason more schools were not included in this comparison was that it seemed desirable to limit the schools to a given geographical area where industrial salary ranges might be somewhat comparable.

The data for national averages were obtained from the Endicott Salary Survey, the Midwest College Placement Association Annual Survey, and the Factory Mutual Engineering Division Survey. It is evident that industry recognizes the graduates of the 5-year curricula by paying them approximately $25 to $50 per month more than the graduates of 4-year curricula. Although I know of no studies by industry to evaluate the relative performances of the graduates of 4-year and 5-year curricula, it would seem that these data on starting salaries are some indication of the regard which American industry holds for the graduates of a 5-year curriculum.

Two questionnaires were mailed in recent years to Ohio State graduates of the 5-year curriculum in an attempt to learn their opinions regarding the curriculum. Each one was sent to a significant number of graduates selected at random. In answer to the question, "Should the 5-year program at Ohio State be continued?", 80% answered *yes* and 17% answered *no* in the first questionnaire, and 81% *yes* with 16% *no* in the second. The replies to the question, "Would you recommend that your son go to an engineering college with a 5-year program?", yielded 76% *yes*, 20% *no;* and 78% *yes*, 18% *no* answers.

Present Curriculum at Ohio State

Our engineering curriculum, like all others in the past 15 years, has undergone evolution. Rather than discuss history, suppose we look at some features of the present curriculum at Ohio State, including changes which were approved by the faculty and Board of Trustees in 1959. Our objectives are the same as those of most schools. I shall try not to bore you with a great many platitudes on this subject. Briefly, our objectives are to educate an engineer with the breadth of training and depth of understanding that will prepare him:

1. To think and communicate logically and effectively;
2. To serve creatively in positions of technical and administrative leadership through a 40- to 50-year career;
3. To have the courage, versatility, and intellectual curiosity to attack new and challenging problems with confidence—not only keeping up with new fields of technology, but guiding the directions they take;
4. To assume his responsibilities in society as an informed and concerned citizen and professional person.

Within the tolerances of academic debate, nearly all educators now agree on these objectives, or some minor modification thereof, although they are frequently stated more eloquently. It is significant to note that these are essentially the objectives held by individuals and schools who might be considered as behind the times, to be polite, in comparison with present trends in engineering education, as well as those who are considered to be ultra-progressive. It is not in the objectives then, but it is in the means to achieve these objectives that differences of opinion exist.

Table 2 shows in summary the curricular changes instituted at Ohio State this year. Stating them rather briefly, Ohio State now has a 2-year pre-engineering curriculum which is essentially common for all students. This curriculum is designed so that students may complete it as students enrolled in the Pre-Engineering Division of our College of Engineering or in accredited liberal arts colleges, either at Ohio State or at other colleges, branch campuses or junior colleges, and at other schools having a comparable pre-engineering curriculum. Upon completion of the pre-engineering curriculum, students will apply for admission to the Professional Division of the College of Engineering, which is now designated as a Professional College at Ohio State—as are the traditional professional colleges of dentistry, law, medicine, pharmacy and veterinary medicine.

Along with these organizational changes, the entire curriculum was strengthened academically by requiring more mathematics for all students, by defining more precisely the courses which meet the social-humanistic requirements—known as "basic education requirements" at Ohio State—and by increasing somewhat the course requirements in the basic sciences, either chemistry for the chemistry-based areas, or nuclear and solid state physics for the physics-based areas. Each branch of engineering increased both the breadth and depth of course content in the engineering sciences and eliminated a number of courses of the so-called "state of the art" variety. The approach for teaching engineering analysis and design of engineering systems was improved in each department and courses were initiated which would permit evaluation of engineering systems of current interest utilizing the preparation in engineering sciences and basic sciences.

Table 3 presents the course requirements in the pre-engineering curriculum. The 93 quarter hours of academic credit include courses in mathematics, chemistry, physics, English, engineering drawing and engineering mechanics. The basic mathematics requirements start with calculus and analytic geometry, and include differential equations and statistics for students in all departments. Most students schedule 15 quarter hours of "basic education" work in the second year and complete the remainder of the requirements in this area during the third, fourth, and fifth years. The only deviation from a completely common program during the first 2 years is a re-

TABLE 2

CURRICULAR CHANGES IN ENGINEERING IN 1959 AT O.S.U.

1. Essentially Common Pre-Engr. Curr.
2. Better Defined "Basic Educ." Courses
3. More Mathematics
4. More Basic Science
5. Greater Breadth and Depth in Engr. Sciences
6. Fewer "State of the Art" Courses
7. Substantial Engr. Analysis, Design, Systems Courses, Reconstituted for Greater Effectiveness

TABLE 3

PRE-ENGINEERING CURRICULUM AT OHIO STATE UNIVERSITY

		Chem.* Based Curr.
28	Math—	
	20 Calc. and Analyt. Geom.	
	5 Diff. Eq.	
	3 Statistics	
9	English	
12	Chemistry, incl. organic and qual.*	(18)
15	Physics	
15	Social—Humanistic*	(9)
9	Engr. Drg., incl. Descrip. Geom.	
5	Engr. Mech.—Statics	
93	qtr. hrs. total	

quirement of 6 quarter hours of quantitative analysis for students who expect to enter the chemistry-based curricula. These students schedule only 9 hours in the basic education area and complete the rest of the requirement while enrolled in the Professional Division.

All colleges of The Ohio State University this past year instituted new general requirements in the social sciences, humanities and natural sciences which are termed the "basic education requirements" in the University. In engineering, these requirements include 5 hours of biological sciences and 35 hours of course work in the social sciences and humanities. Each student elects courses from an approved list of courses which are considered to meet the spirit of these objectives.

As shown in Table 4, a minimum of 15 quarter hours of credit is required in both the social sciences and the humanities areas. All students must earn at least 5 hours of credit in history and a minimum of 5 hours in political science, sociology, geography, or psychology, and complete a sequence of two or more courses in the social sciences area. In the humanities area, all students must earn at least 8 hours of credit in literature and 5 hours in fine arts, music, philosophy or drama. It should be noted that credit in English, technical writing, or speech is not counted toward meeting the requirements in basic education. Neither are such courses as

TABLE 4

OHIO STATE'S "BASIC EDUCATION REQUIREMENTS" IN ENGINEERING

5	Biological Science
35	15 Social Science (include sequence) 5 History 5 Economics, Geography, Political Science, Psychology, Sociology 15 Humanities 8 Literature 5 Music, Drama, Fine Arts, Philosophy
40	qtr. hrs. minimum

business organization, accounting and business law. While these courses are required in the curricula of some branches, and are electives in all branches, they are taken in addition to the 40 hours defined as "basic education requirements."

Table 5 indicates the advantages which the engineering faculty at Ohio State believe can be achieved as a result of these latest curricular changes. The engineering curriculum is recognized as a professional curriculum at Ohio State, along with the traditional professional colleges, reflecting the growing awareness of professionalism for engineers. Students will have nearly two years in which to decide on their major branch of engineering. By the nature of the pre-engineering program, arrangements for transfer from other colleges to the Professional Division in engineering will be more flexible, thus making transfer easier for the student with little or no time lost in partial duplication of previous course work. It will also make it possible for students wishing to attend a school near their home to do so. Stu-

TABLE 5

ADVANTAGES WHICH SHOULD BE ATTAINABLE WITH THE NEW PROFESSIONAL PROGRAM

1. Gives Engineering Professional Status
2. Allows Student Two Years to Choose Major
3. Facilitates Transfers from L.A. Colleges, Branch Campuses, Junior Colleges, etc.
4. Affords Better Screening for Adm. to 3rd Yr.
5. Provides Natural Terminal Point for Some Students

dents must maintain a "C" average, or higher, in their pre-engineering courses to be eligible for admission to the Professional Division in Engineering. Because of the greater selectivity of students who will be permitted to enroll in the Professional Division program, most students who are admitted should be able to graduate, which should result in more effective use of time for both faculty and students, as well as of university facilities. Those students who show questionable interest or academic ability in engineering may terminate their engineering studies at the end of the pre-engineering program with some pride of accomplishment.

Combined Bachelor's and Master's Program

One important feature of the 5-year curriculum at The Ohio State University is the Combined Bachelor's and Master's Degree Program for those outstanding students who rank in the upper 10–15% of their class. Under this program, students who maintain a "B" average, or higher, may petition for concurrent registration in the graduate school during their last year and are eligible to receive the degree Master of Science, as well as the Bachelor's degree, at the end of the 5-year program. Most eligible students need about 1 additional quarter to complete the requirements for both degrees. This is an educational program which permits the superior student to follow a research-oriented curriculum with additional emphasis on mathematics, basic science, and engineering science. This curriculum might be termed an engineering science program, and is comparable to the work taken by students in most 4-year engineering science curricula followed by work for the Master of Science degree. It is a graduate-level program in every respect, since the students in the last year are registered only in graduate courses and are in association with other graduate students. In most departments, the student who anticipates admission to this program makes some adjustments in his fourth-year schedule so that he will be prepared to register in graduate courses only during his fifth year. In essence, this is an honors program which recognizes the greater learning capacity of the outstanding student and not only permits him to embark on a more challenging program but rewards him in a manner commensurate with his ability. As such, we believe it is one of the best "honors" or "merit" programs yet devised.

Comparison of 5-Year and 4-Year Curricula

To give some measure of comparison between the new curriculum at Ohio State and the present curricula of both 5-year and 4-year schools, Tables 6, 7, 8, and 9 are presented. These tables list the number of quarter hours of credit required in the areas of mathematics, basic science, engineering science, engineering analysis, design and engineering systems, non-technical electives, English, engineering drawing, and electives. It will be recognized that these categories are consistent with those listed in the "Report on the Evaluation of Engineering Education, 1955." Recognizing the possible inaccuracies of trying to evaluate a course from its title, or even from

TABLE 6

COMPARISON OF 5-YEAR AND 4-YEAR CURRICULA IN MECHANICAL ENGINEERING
Equivalent quarter hours of credit

	Math	Basic Science	Engr. Science	Engr. Anal., Design, Systems	Non-Tech.	Engl.	Engr. Drwg.	Elect.
O.S.U.	28	32	60	58	42	9	9	12
Ave. 4 Yr.	25.7	30.5	50.7	39.7	28.9	8.2	6.6	15.6
Range, 4 Yr.	18–33	23–39	36–68	23–57	18–40	0–13	0–12	5–30
Ave. 5 Yr.	27.7	36.2	68.2	51.7	40.6	10.5	9	18.8

TABLE 7

COMPARISON OF 5-YEAR AND 4-YEAR CURRICULA IN ELECTRICAL ENGINEERING
Equivalent quarter hours of credit

	Math	Basic Science	Engr. Science	Engr. Anal., Design, Systems	Non-Tech.	Engl.	Engr. Drwg.	Elect.
O.S.U.	34	33	63	47	40	9	9	22
Ave. 4 Yr.	27.4	31.8	44.4	38.5	28.7	7.8	5.5	21.2
Range, 4 Yr.	20–42	22–45	23–58	17–52	18–40	0–12	0–9	9–45
Ave. 5 Yr.	28	36.5	57	61.7	39.3	11.6	8.2	18.8

its catalog description, the curricula in mechanical engineering, electrical engineering, civil engineering and chemical engineering at 24 schools were evaluated in terms of the equivalent number of quarter hours of credit required in each of the aforementioned areas. All data were taken from 1959–60 engineering bulletins.

Twenty 4-year curricula were included in the study: University of California (Berkeley), University of California at Los Angeles, California Institute of Technology, Carnegie Institute of Technology, Case Institute of Technology, College of City of New York, Georgia Tech, University of Illinois, Illinois Institute of Technology, University of Iowa, Iowa State University, Massachusetts Institute of Technology, University of Michigan, Michigan State University, Northwestern University, Pennsylvania State University, University of Pittsburgh, Purdue University, Rensselaer, and the University of Wisconsin.

The averages presented in Tables 6, 7, 8 and 9 for the 5-year curricula are for Cornell University, University of Min-

TABLE 8

COMPARISON OF 5-YEAR AND 4-YEAR CURRICULA IN CIVIL ENGINEERING
Equivalent quarter hours of credit

	Math	Basic Science	Engr. Science	Engr. Anal., Design, Systems	Non-Tech.	Engl.	Engr. Drwg.	Elect.
O.S.U.	28	37	51	62	38	12	9	12
Ave. 4 Yr.	24.6	33.5	41.5	54.3	27.6	8.3	6.6	11.7
Range, 4 Yr.	18–33	26–42	23–54	38–73	15–40	0–13	0–12	0–30
Ave. 5 Yr.	26.5	37.9	53	68.8	41.3	10.5	9.5	13

TABLE 9

COMPARISON OF 5-YEAR AND 4-YEAR CURRICULA IN CHEMICAL ENGINEERING
Equivalent quarter hours of credit

	Math	Basic Science	Engr. Science	Engr. Anal., Design, Systems	Non-Tech.	Engl.	Engr. Drwg.	Elect.
O.S.U.	31	69	45	44	40	9	9	12
Ave. 4 Yr.	25.2	60.6	33.2	37.3	26.8	8.3	5.0	12.3
Range, 4 Yr.	17–33	29–69	21–48	26–55	12–40	0–13	0–9	0–24
Ave. 5 Yr.	28.3	71.2	41.7	43.2	42.7	10.5	5.6	15.8

nesota, Ohio State University, and Rice Institute of Technology.

In making the comparison it was evident that many courses should be listed in still another category labeled "state of the art" and not actually in the engineering analysis, design, and engineering systems category. However, in most cases, it would be impossible to judge on the basis of course descriptions alone whether certain courses listed were taught with primary emphasis on the "state of the art" or whether in fact pertinent applications of mathematics, basic sciences, and engineering sciences were employed in the analysis and design of a modern engineering system. Giving the benefit of the doubt to many courses of this kind, they were all placed in the single category. In the new curriculum, Ohio State has kept very few courses of the "state-of-the-art" variety, as stated earlier.

The engineering sciences and basic sciences categories include only the types of courses so described in the "Report on the Evaluation of Engineering Education, 1955," and the following ASEE "Report on the Engineering Sciences, 1956–58." Since many schools permit a substantial number of hours of business courses and speech as a part of their social-humanistic requirements, such courses were listed in this category for all schools and the category was labeled "non-technical." This means, however, that the average number of credit hours devoted to the social-humanistic courses is not as high as the average in the non-technical category would indicate.

The tables include credit for academic subjects only. Credit for basic ROTC, physical education, inspection trips, summer work experience, and freshmen survey courses are not included.

Tables 6, 7, 8, and 9 show that the 5-year program includes time for more course work in every category than the average for the 4-year curricula studied. The range of hours required in each of these categories by the 20 four-year schools studied shows that some schools devote as much time to a few of these areas in a 4-year curriculum as the average for the 5-year curricula listed. Further study of the individual curricula, however, reveals that whenever a 4-year school has as many hours devoted to one or two categories as a 5-year school, that curriculum devotes considerably less than the average amount of course time to some other categories.

Conclusion

Hence, the greatest strength of the 5-year curriculum is the fact that adequate time may be devoted to the increasingly important areas of mathematics, basic science, engineering science, and the social-humanistic areas and, at the same time, a significant portion of class time is available for the analysis and design of engineering systems. It is this latter area, as well as the engineering science area, which distinguishes an engineering curriculum from a curriculum in the pure sciences. The former areas are essential in providing the academic background necessary for future development in the profession. But if either the engineering analysis and design area or the engineering science area is trimmed drastically in order to provide time for the other areas, where is the engineering in the engineering curriculum?

Most embryo engineers need the opportunity to apply the principles learned in their engineering science courses to the synthesis, design, and analysis of integrated engineering systems; and, under the guidance of experienced professors, they begin to appreciate some of the design compromises and considerations for economics, reliability, safety, maintenance, and manufacturing feasibility, which later in their careers become the essence of experienced engineering judgment. A few of the better students sense these applications and compromises intuitively, but most students must learn them through experience—some of which should start in college.

If engineering education is to prepare young people adequately for careers in engineering, it seems essential that the engineering curriculum must devote substantial time to both the engineering sciences and the analysis and design courses.

After 15 years' experience with a 5-

(*Continued on page 724*)

Graphics from the Viewpoint of Industry

LEONARD A. NELSON

Boeing Airplane Company
Wichita Division

The Football of the Engineering Curriculum

As educators are zealously enlarging the engineering curriculum to meet the challenge of the space age, industry is struggling to design, develop, and produce products on a highly competitive military or commercial market. Strange sounding fields of scientific endeavor have come into being, such as orbital flight mechanics, energy conversion, hypersonic, magneto-hydrodynamics, and plasma physics.

Just where does graphics fit into this picture? Does it contribute anything to technological advancement in the space age? It has apparently been the football of the engineering curriculum in recent years. We understand that many new science courses have been added to the college curriculum. And to make room for the new courses, many schools have reduced the time for instruction in engineering drawing and other graphics courses to a level that is something less than a bare minimum. We have even heard of suggestions to leave graphics to the secondary school or to make it a subfreshman, non-credit exercise. Perhaps we are guilty of understatement to say that graphics has been deemphasized.

No doubt all of us are also familiar with the threat aimed at sound drafting practices by the so-called "simplified drafting" philosophy. If we would give our full-fledged support to this school of thought, we could not justify the time we now spend teaching graphics. Suffice it to say at this point that simplified drafting has some good principles, many of which were adopted by the airframe industry years ago, but many of the new concepts of simplification have not been approved by industry as a whole or by authorized standardizing agencies. Nevertheless, as members of industry and as educators we should be constantly on the alert to evaluate any new or different practices and then discard methods that have become obsolete, or adopt those that have merit.

Presented at the Engineering Graphics Division's Midwinter Meeting in Wichita, January 19, 1961.

Automated Drafting

Now I would like to pull a specter out of the closet that is destined to have far reaching affects upon graphics; and I would like to give it the recently coined term: "Automated Drafting."

Figure 1 shows a picture of the Boeing-Wichita designed Plotter-Verifier, which is capable of drafting from instructions dictated by computer tapes. This is not just an idea that will be developed at some future time, but it is a machine that is here now and is in use. This machine was constructed originally for verifying magnetic tapes used for numerical control machining of airplane parts, but it also has the capability of making line drawings, airfoils, three view drawings of parts, charts, maps, or any other drawing that can be defined through the use of computed point data. Notice the tape in the computer cabinet and the ball point pen that responds to instructions from the tape to move in X, Y, and Z directions.

The possibilities inherent in this method of drafting are unlimited. As an example, an NACA airfoil similar to the one shown in Figure 2 was plotted manually and subsequently by the plotter-verifier with results as follows: The automatic equipment plotted the foil section in one-

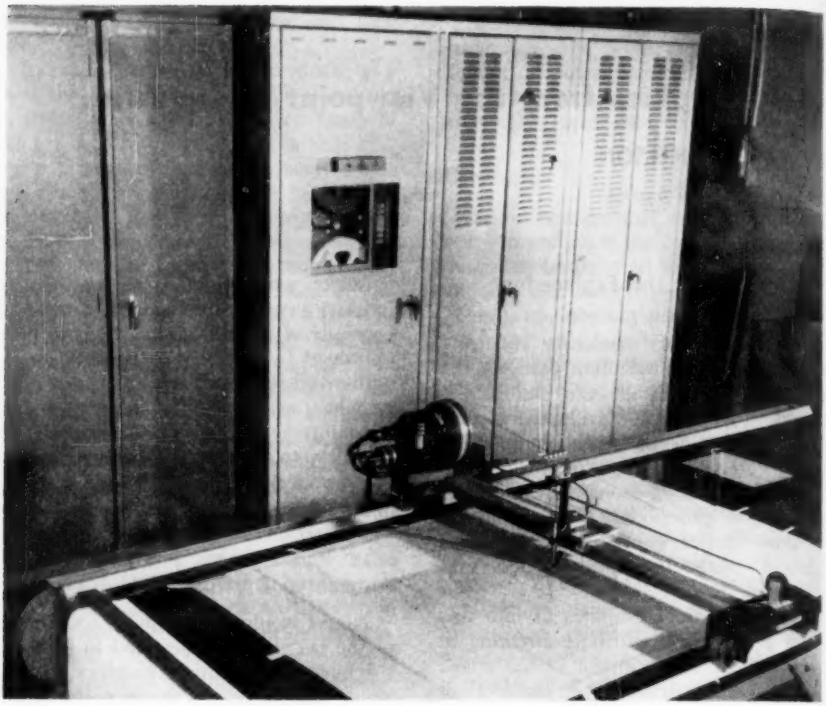


FIG. 1.

third the time that was required to do it manually. The machine-produced foil section was also more accurate because the manual method had to employ the use of a spline to fair the curved lines from point to point, whereas the computer can be asked to produce a line correct to two thousandths of an inch by the use of sub-routines that create many additional points on the curves. Then simply by changing the dimensional input of the computer, the plotter can prepare foil sections with varying chord lengths. The savings in time and the increase in accuracy are significant, but there is an added bonus in that once the tape is prepared, it can be catalogued and stored. At any future time the foil section can be reproduced within seven to ten minutes.

We have not asked the plotter-verifier to give us a three-view drawing of a part, but Figure 3 illustrates that it can be done. Once a given set of lines are shown in one view, the computer can be asked to show the lines from another angle. Shown are the three views of a cutter-path trace used in machining a large die.

Flight test data of aircraft and missiles can be plotted in a fraction of the time previously required.

FIG. 2.

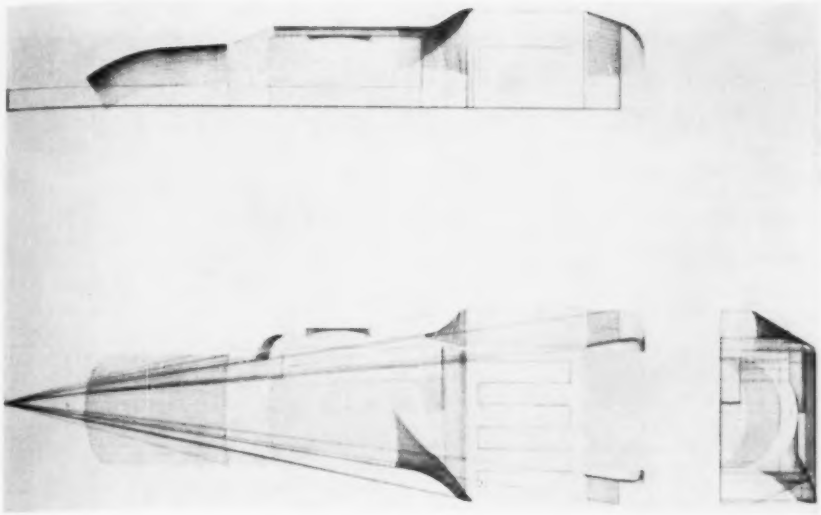


FIG. 3.

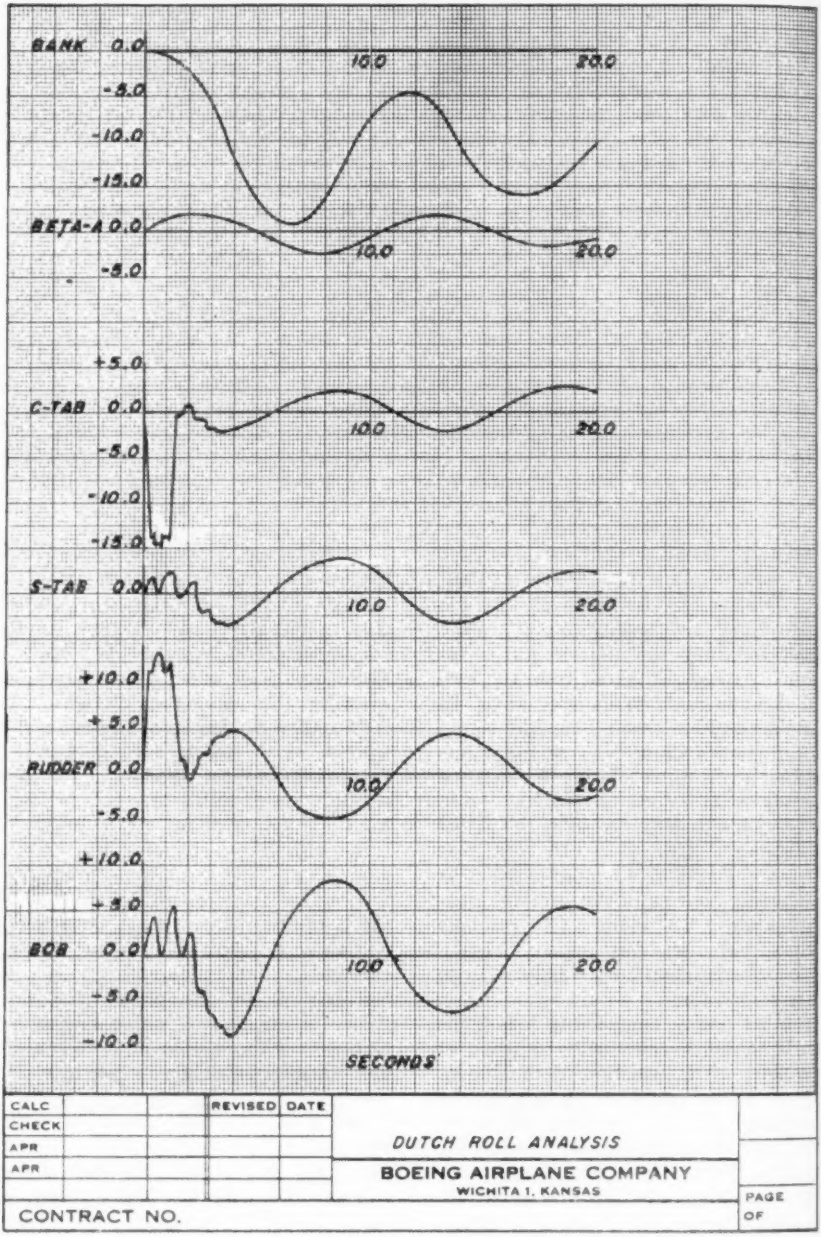
Figure 4 shows a plotted graph of a typical Dutch Roll Test. "Dutch Roll" describes a flight condition that is peculiar to all swept-wing aircraft. The graph indicates the time required for oscillations and deviations from the normal flight attitude to dampen out. To plot the resulting curves manually would be extremely tedious because the points on the curves, especially for the first two seconds of time duration, would have to be very close together to show the actual oscillations. This particular test was machine plotted in 43 minutes whereas the manual drafting of the same information required 13 hours. The machine input included standard numerical equations of motion, and constants peculiar to a given airplane.

Further, many engineering man-hours can be saved by automated drafting of equations. The equation at the top of Figure 5 was used to determine the power gain of a narrow-beam antenna at any angle from the center line of the antenna's main lobe. The pattern was drawn in minutes by the plotter-verifier. Its completeness and accuracy could not be duplicated by a draftsman in many hours of laborious work. The computer calculated points for every 10th of a degree. Thus if this had been done manually, 3,600 separate computations would have been required.

It appears also that the computer will be making giant inroads into another field of graphics, perspective drawing. Techniques have already been developed whereby the computer, plotter-verifier combination can be asked to draw a perspective of an object or a model from a given point of view. See Figure 6. And should it be desirable to view the model from a different angle, this can also be accomplished by changing the angular input data. The actual techniques used to program the drawing shown in Figure 6 is proprietary, but I believe you will agree that this is an eye-opener regarding computer capabilities. After the machine plotter completed the lines shown in Figure 6, it was a simple task to trace off the visible lines and add a little shading as shown in Figure 7.

Our company is in the act of urging its design groups to make more use of this equipment. I have shown only a few of the many applications for the plotter-verifier. We have just begun to explore its possibilities.

A parallel development in the field of drawing automation could be termed "mockup simulation." This is a concept that will have far-reaching effects on


BANK 0.0
-5.0
-10.0
-15.0
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BETA-A 0.0
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C-TAB 0.0
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S-TAB 0.0
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RUDDER 0.0
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BOB 0.0
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BOEING AIRPLANE COMPANY
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FIG. 4.

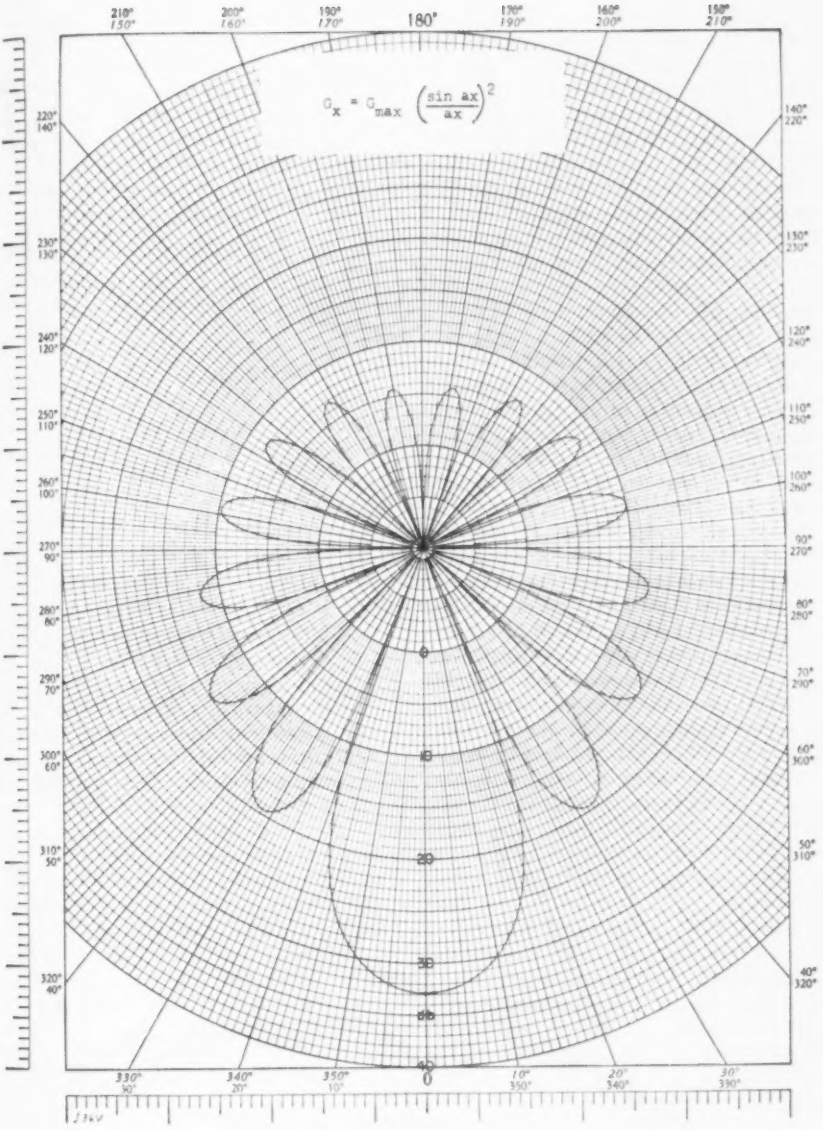

FIG. 5.

graphics requirements of engineering activity especially in the electrical, hydraulics, and equipment areas. It might be defined as a technique of developing a mathematical model of a product, such as an airplane, within a computer on which can be performed many of the functions presently performed on a physical mockup.

A mockup is an exact replica of a finished product, or portion thereof, constructed of relatively cheap and easy to work materials and used to perform the following typical functions:

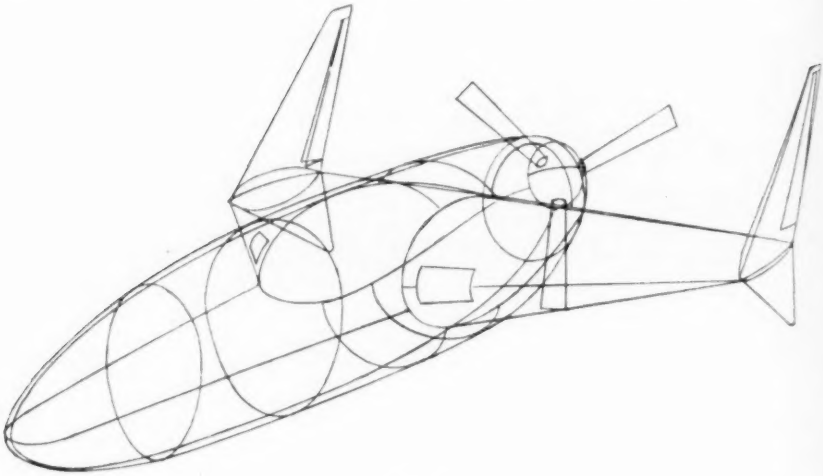

FIG. 6.

1. Space allocation or the actual physical locating of equipment and components within the product. An airplane such as the B-52 which has a gross weight of 488,000 lbs., consists of approximately 65,000 lbs. or 15% of equipment other than airframe. Since the available space within the airplane to locate this equipment is very small, the allocation of this space is extremely critical. This problem, further complicated by the constant design improvement changes which require continuing relocation, points up the need for a more simple system for controlling space allocation.
2. A mockup is also used to facilitate wire and tube routing. Up until the present the most practical and

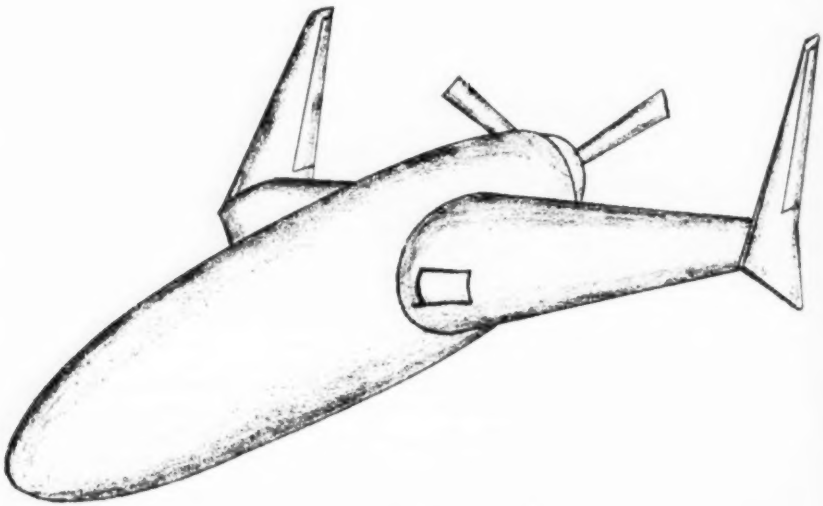

FIG. 7.

economic way of determining exact wire and tube routing, lengths, etc., has been on a physical mockup. This system, when applied to a product as complex as a B-52H which contains over 68 miles of wiring and 28,000 feet of high pressure tubing, is very costly in terms of time and manpower.

Under the mockup simulation concept, a mathematical model is created and held within the memory of a computer. This is accomplished by defining in terms of three dimensional coordinates or other descriptive mathematical language, the exact space occupied by each item of structure and equipment of the product within the limits of its over-all envelope. With this information available within a computer, it will be possible to determine very rapidly and exactly what space remains available within which equipment can be located, the best possible location for wire and tube routing, and the answers to practically any questions for which a physical mockup is now used.

A few of the more obvious advantages to the use of mockup simulation would be:

1. Less engineering time required to accomplish basic wire and tube routing as well as subsequent changes.
2. Reduction of errors.
3. Better engineering control over space allocation and wire and tube routing. Now this is largely left to manufacturing planning.
4. Better center of gravity control.
5. Better optimum arrangement of installations for space conservation.

Industry's Need for Engineers with Graphic Skills

In view of the above mentioned innovations in the field of graphics the questions arise: Will the requirements for the draftsman diminish in the immediate future and should education in graphics be deemphasized further? The answer to both questions is a decisive "NO." The casual observer might conclude that fewer drawings are required for today's missiles and tomorrows space vehicles. But publications in the graphics field disclose that the average missile with its sophisticated control system requires better than 15,000 drawings, a jet fighter 30,000 drawings and the advanced space vehicles now in planning stages may require upward of 100,000 drawings. The military is receiving drawings at the rate of six million a year. This rate is on the increase, because greater sophistication of weapon systems requires a correspondingly greater amount of drawing delineation.

The popular reaction to this tremendous requirement for drawings is to shrug one's shoulders and say that the preparation of all these drawings could be given over to the draftsman or perhaps automation will somehow come to the rescue. This is head-in-the-sand type thinking. My experience tells me that a very large percentage of the drawings mentioned are brought into being by the graduate engineer. And as far as automation is concerned, it is making its appearance slowly and we will always need personnel that can determine whether or not the machine is right. The personnel that program the information into the machine must have the necessary engineering and drawing backgrounds. At present the information received from the machine must be finished by drawing and lettering, and someone is always needed to correlate the machine output into usable drawings. Here again, the knowledge and abilities of the graduate engineer are required.

Boeing-Wichita is not alone in assigning numerous drawing preparation tasks to the graduate engineer. In managing a multi-million dollar engineering subcontract effort, we find that some firms have decreased the ratio of draftsmen to engineers to the extent that practically all of the drawing preparation is being accomplished by qualified engineers.

The requirement for engineers with graphic skills is substantiated by a specific look at the B-52 picture. This airplane has required some 35,000 Boeing numbered drawings. Not included are the many vendor drawings that have been submitted to fulfill Boeing design requirements. Then, to keep pace with today's dynamic weapon systems, the

average drawing must be changed many times either directly or by advance change notices. At Boeing-Wichita these advance change notices total over 5,000 a month. Who is to do this work? It is drafted by, or at least checked by, or supervised by, or used by the graduate engineer.

We cannot even say that the airframe manufacturer enjoys free reign over how to prepare his drawings, what to include on his drawings, and how well to prepare his drawings. If some branch of the Military is his customer, the manufacturer finds in his contracts directives that require him to comply with specific drafting specifications, such as the controversial MIL-D-70327, entitled Engineering Drawings and Associated Lists. This specification exercises tremendous control over the drawing. It calls out military standards that control general drawing practice, drawing sizes, format, dimensioning, abbreviations, symbols, revisions, titles, numbering, parts lists, drawing media, and quality. Yes even quality! The specification asks the design activity to check the drawings not only for completeness and technical accuracy but for legibility and reproducibility. The government also reserves the right to review the drawings prior to acceptance and could reject them for quality reasons. Information filters through to industry that a general across the board dissatisfaction with present drawing quality exists among the military. At various occasions the military has called attention to contractor-prepared drawings that are very poorly executed and nearly illegible. Blowback from aperture card microfilm would make matters even worse. MIL-D-70327 also implies that when the military buys an article they obtain drawings adequate in all respects for manufacture or for competitive procurement. The tight interchangeability and replaceability requirements imposed by MIL-I-8500 must also be reflected on the engineering drawing by dimensional accuracy and specific callout. Does this all sound as though drawing preparation is becoming less significant?

We have already mentioned microfilm. It is here to stay. Military problems of engineering data storage have reached the point that a system of microfilming drawings becomes imperative. As a result, the microfilm specification MIL-M-8857 has come into being. Aperture card microfilm is being introduced simultaneously by several branches of the Service. Without doubt, greater demands will be made on drafting legibility. Drawings will have to be prepared carefully, lines uniform in thickness, notes carefully printed and widely spread. We can forget the free-hand sketches recommended by the proponents of simplified drafting. Some chief draftsmen in industry are fearing more detailed requirement from the Military even relating to lettering slant, letter height, line density and line width. Does this indicate that we can begin relaxing in the area of graphics and abandon it as a more or less unimportant skill that the engineer should have picked up in secondary schools?

An engineering graduate who has not received the fundamentals of graphics often becomes a problem to the airframe company. Many engineering new hires must be given training in drawing preparation on company time before they are put to work in a design group, or if this training is not available because of austerity programs, the new engineer may find it necessary to take supplementary off-shift graphics training. In such courses it often becomes necessary to spend considerable time with practice in line and lettering work. It is surprising to see that graduate engineers from some colleges and universities are not able to draw a line that would reproduce properly or construct an acceptable alphabetical character. Place yourself into our position. What assignments can we give these engineers so that they can earn their way until we can give them advancement? Often they do not have the capabilities required to begin their career. Who should we use to prepare the 35,000 B-52 drawings? At least at Boeing a significant percentage of new engineering graduates will spend their early years of service in assignments which will include the preparation, checking or changing of drawings.

Certainly a company as large as Boeing has engineering personnel who are exploring the unknown, who are researching and developing space age concepts in the search for products for tomorrow's markets, but the backbone of our engineering activity is comprised of those who prepare the drawings that serve as the communication link between the scientist-engineer and the production shops in the manufacture of today's products.

To be sure, many engineering departments have a number of supporting units and groups that are not concerned primarily with drawing preparation. I mention only such functions as field service, structural dynamics, flight test operations, human factors reliability, and aerodynamics. However, those in charge of personnel placement do not consider design experience on the drawing board a hindrance to acceptance of positions in these areas. On the contrary, a solid background in drawing and design constitutes a tremendous asset to the record of any engineering employee. The drawing room is industry's handiest manpower pool for filling good engineering positions. Many a project engineer has been heard to speak proudly of his drafting and design background.

Challenge to Education

My advice to education is to place sufficient emphasis on the teaching of the fundamentals of graphics. Teach the best practices of engineering drawing in spite of the cut in the amount of time allotted in the curriculum. If the educator fails to equip the engineering graduate with a thorough knowledge and skill in graphics either the so-called technical institutes will have to begin supplying industry with personnel they can use or industry will have to create on-the-job training classes to prepare the young engineer for his job. Training by industry is expensive not only in dollars but in time requirement on the engineer. This requirement delays the company in assigning the neophyte to the specific task for which he has already devoted five or more years of preparation.

Educators can also help industry by putting the young engineer in the proper state of mind. When a young lad dreams of becoming a fireman, he sees himself at the wheel of a speeding red fire wagon with sirens screaming. He does not see himself studying the city map or scrubbing the floors of the fire station. Similarly the young engineer enticed into employment by the colorful brochures of a great company, pictures himself as a young scientist engaged in new, fantastically challenging fields of work. He pictures himself toying with models of space age vehicles or conducting tests on the laboratory equipment of tomorrow. But alas, when he is ushered through the doors of an engineering organization to meet his new employer, he receives a tall stool and a drawing table. What a letdown! He accuses his professors of not preparing him for his work or he may accuse his employer of misleading him.

Let's cultivate in the young engineer the desire to acquire the tools of communication, including the basic fundamentals of graphics, so that he may communicate his ideas accurately and effectively with others. Drawing preparation is not a menial task. It should challenge the best efforts of an engineer. A poorly prepared drawing has no place in today's competitive market. Our company takes professional pride in its drawings as well as its products.

True, it is not necessary or desirable that top flight engineers continue to spend long hours on the drafting board actually preparing drawings. However, it is desirable that they know as much or more about the theories and fundamentals of a good drawing than the professional draftsman. Let's tell the young engineer that the real creative engineering is done in the drafting room and that his work in design and drawing preparation is the keystone of his engineering career. The graphic skills of a young engineer are a tool which he will use to express somebody else's ideas today and possibly his own ideas tomorrow. The most valuable men in engineering research and development areas are those whose solid background in drawing and design permits them to follow a task from the initial

freehand sketch to the finished article. Drafting is by no means losing its place as an engineering tool.

No doubt educators have access to all the latest literature available regarding drawing media and miscellaneous drafting equipment and supplies that have appeared on the market recently to improve the efficiency of the draftsman. Therefore industry assumes that drawing courses are being revised constantly to keep up to date with the state of the art. Are you aware that Boeing-Wichita is one of perhaps many firms that have made a 100% switch-over from linen to a polyester film?

Because of its greater durability, economy, stability, and reproduction qualities, a polyester film will probably become the chief drawing medium of the future both for dimensioned and undimensioned drawings. Here is another understatement; drawing preparation on polyester is a far cry from preparing a plate on buff card stock. My intention is not to cast reflections that educators are using obsolete drawing materials, but I would urge that the young engineer be initiated in the use of new drawing media, such as Mylar; he should receive more direction regarding the selection of proper pencils and erasers to achieve the best results on a given drawing surface. And what about those beautiful sets of foreign made drawing instruments? They are certainly a masterpiece of art and craftsmanship, but their utility in recent years is becoming less and less. You would have difficulty finding a set in use among aircraft engineers and draftsmen.

In conclusion I would like to quote the first sentence of the recently translated German book *History of Technical Drawing* by Franz Feldhaus.

"From the time man began to think, invent and actively create, he has endeavored to express his thoughts pictorially, both for his own assistance and to make himself understood by others."

Herein is the essence of graphics. The passing centuries have brought about new concepts and improvement in methods; nevertheless industry's need for the pictorial communicator will remain. Industry will continue looking for graduates equipped with a thorough understanding of graphic principles and with the skill required to execute neat and accurate drawings.

Five-Year Engineering Curriculum

(*Continued from page 714*)

year engineering curriculum, most members of the faculty at Ohio State believe that a 5-year curriculum provides a balanced coverage of all phases of education for the profession in a reasonable length of time; and, with the Combined Program, it allows the superior student to earn a master's degree in the same period of time as in a 4-year curriculum followed by graduate work.

Engineering Technical Institute Enrollments and Graduations in ECPD-Listed Institutions: 1958

KEN AUGUST BRUNNER

D. GRANT MORRISON

Introduction

This is the third article in the series of reports of enrollments and graduations from ECPD-listed institutions in various semi-professional fields.[1]

[1] Henry H. Armsby and S. V. Martorana, "Engineering Technical Institute Enrollments and Graduations in ECPD-Listed Institutions: 1956," *Journal*, Vol. 48, No. 9 (May 1958), pp. 772–785.

Dr. Brunner is Specialist for Associate Degree and Related Programs, Higher Education Programs Branch, and Dr. Morrison is Specialist for Community and Junior Colleges, College and University Administration Branch, both in the Division of Higher Education of the Office of Education, U. S. Department of Health, Education, and Welfare. *The two basic tables of this report were prepared by Leah W. Ramsey, under the supervision of Hazel C. Poole, and further refined by Barbara L. Mauer.*

The term "ECPD-Listed Institutions" is used in this report to designate institutions in which at least one curriculum is accredited by the Engineers' Council for Professional Development (ECPD), a nationally recognized accrediting agency for engineering schools and technical institutes. ECPD accredits only individual curriculums. These are referred to as "ECPD-accredited curriculums."

The more inclusive study from which the data used in this report are drawn is reported in United States Office of Education Circular 632, Organized Occupational Curriculums in Higher Education: Enrollments and Graduates, 1958.

Within the last year or so a number of publications have outlined the continuing necessity for the increasing use of technicians in our economy as supporting personnel to engineers and scientists. In many cases, as is well known, engineers and scientists are performing the work of technicians because technicians have not been available and are not yet available in sufficient numbers to perform these tasks. It is a cause of some concern then to note that in 1958 and again in 1959 freshman engineering enrollments declined 11.1 per cent and 3.3 per cent respectively.[2] The Engineering Manpower Commission in cooperation with ASEE made a special study of technical institute enrollments in 1959 to determine whether there was some relationship between the freshman enrollments in engineering colleges and first-year enrollments in technical institute programs. They surveyed only those technical institutes offering curriculums accredited by the Engineers' Council for Professional Development. On the basis of complete returns from 22 technical in-

Ken August Brunner and D. Grant Morrison, "Engineering Technical Institute Enrollments and Graduations in ECPD-Listed Institutions: 1957," *Journal*, Vol. 50, No. 2 (November 1959), pp. 136–151.

[2] Justin C. Lewis and Henry H. Armsby, *Engineering Enrollments and Degrees 1958*. Office of Education Circular No. 555. (Washington: U. S. Government Printing Office, 1959), p. 9.

Wayne E. Tolliver and Henry H. Armsby, *Engineering Enrollments and Degrees 1959*. Office of Education Circular No. 617. (Washington: U. S. Government Printing Office, 1960), p. 10.

stitutes they concluded, "There does not appear to be any gain in the two-year program enrollments at the expense of the engineering colleges."[3]

The data which are presented in this article and which are based on a much wider sample tend to substantiate the report of the Engineering Manpower Commission. A further significance of this brief survey by the Engineering Manpower Commission is the clear indication of the importance placed on analyses of technical institute enrollments and graduations such as are presented in this series of *Journal* articles. Surveys like that of the Engineering Manpower Commission and those by Donald C. Metz[4] should probably be repeated from time to time to get quick snapshot impressions of technical institute enrollments. Resulting tentative predictions and conclusions can be tested later against the more complete data obtained in the annual survey of *Organized Occupational Curriculums* which is conducted by the Office of Education in cooperation with ASEE.

On May 24, 1959 the White House published *Education for the Age of Science*. This report by the President's Science Advisory Committee, chaired at the time by Dr. James R. Killian, Jr., Special Assistant to the President for Science and Technology, stated that in America the technical institute has been grossly neglected. *Education for the Age of Science* declares that the technical institutes should be enlarged and improved, that their graduates are needed in much greater numbers than they are being produced, and that the occupations for which technical institute graduates are prepared deserve greater dignity and prestige.

The report of the National Survey of Technical Institute Education, which was conducted by ASEE, was published in *The Technical Institute in America* written by G. Ross Henninger, Director, and published by McGraw-Hill Book Company, Inc., 1959. Among the findings was a ratio of employed engineering technicians to engineers of about 0.8 to 1. Employers had also been asked to state their *preferred* ratios at the time, five years later, and ten years later. Two conclusions were reached with regard to the employment situation for engineering technicians throughout the country at the time of the survey: (1) About 30 per cent more were needed than were available; (2) by 1967 employers would like to hire more than twice as many graduates from technical institutes as from engineering colleges, at the same time expecting to increase their demands for engineering graduates.[5] Thus, it seems clear that the need for engineering technicians will continue to increase at an even greater rate than in the past.

Partly to find out the extent to which higher educational institutions were meeting this need, the U. S. Office of Education, in cooperation with ASEE, undertook a series of annual surveys of organized occupational curriculums beginning with the 1955–56 academic year. Data from the first two joint surveys were used to prepare the first two articles in the *Journal* series of reports of enrollments and graduations from ECPD listed institutions in various semi-professional fields. Data for this article are drawn from all three surveys of organized occupational curriculums.[6]

Definition of Field Covered

Specific criteria for organized occupational curriculums are defined in the questionnaire in this manner:

For purposes of this survey, an organized occupational curriculum is one which meets *all five* of the following criteria:

a. High-school graduation (or its equivalent), but no work beyond

[3] "Trends in Technical Institute Enrollment." (New York: Engineering Manpower Commission, August 1959). Mimeo. p. 1.

[4] *Technical Education News*, Vol. 19, No. 1 (Special Issue, 1959), p. 13; *Technical Education News*, Vol. 20, No. 2 (November, 1960), p. 15.

[5] Pp. 130–133.

[6] In some instances in the present article, 1956 and 1957 data are treated different from the way they were treated in the first two *Journal* articles in this series. Comparisons between data in this and previous articles should, therefore, be made with care.

the high school, is required for admission to the curriculum. The general level of these curriculums is the first one to three years beyond high school.

b. The curriculum is a series of required and elective courses constituting an integrated program prescribed by the institution to assist in the general education and training of the individual, but more particularly, in his training as a future practitioner in a given occupation or cluster of occupations. A group of courses, even though all of them be in a given occupational area, does not necessarily constitute a curriculum.

c. The curriculum is designed to prepare students for immediate employment in an occupation or cluster of occupations, rather than for further, advanced study leading to a bachelor's or higher degree. Nevertheless, individual courses in the curriculum may normally be creditable toward a bachelor's or first professional degree by transfer or otherwise. However, the curriculum as an organized program, as distinguished from the individual courses in it, is designed to educate and train primarily for occupational competence rather than for transfer or degree credit. *The curriculum, itself, and its objectives should be classified, not the intentions or possible subsequent careers of the students involved.*

d. Completion of the curriculum requires *at least 1 but less than 4 years* of full-time attendance, or the equivalent in part-time attendance over a longer period. A "year" means an academic year of approximately 9 months.

e. The curriculum leads to a certificate, diploma, associate degree, or other *formal award*, signifying that the student has completed an *organized* curriculum in an occupational area; or the State grants a license or other formal recognition, without examination, to all graduates of the curriculum.

Each of these factors is important. Again, as was the case in previous years, curricula had to be eliminated before data could be summarized because some of the reported programs were unable to satisfy all of the factors listed above.

"Technician" has been defined parallel to the definition adopted by the President's Committee on Scientists and Engineers:

> The engineering or scientific technician is usually employed in (1) research, design, or development; (2) production, operation, or control; (3) installation, maintenance, or sales. When serving in the first of these functional categories, he usually acts as direct supporting personnel to an engineer or scientist. When employed in the second category, he usually follows a course prescribed by a scientist or engineer but may not work closely under his direction. When active in the third category, he is frequently performing a task that would otherwise have to be done by an engineer.
>
> In executing his function the scientific or engineering technician is required to use a high degree of rational thinking, and to employ post-secondary school mathematics and the principles of physical and natural science. He thereby assumes the more routine engineering functions necessary in the growing technologically based economy. He must effectively communicate scientific or engineering ideas mathematically, graphically, and linguistically.

This definition is used to distinguish technicians from artisans, craftsmen, and skilled operators.

Information Sought by Questionnaire

The questionnaire was addressed to the registrar of the institution, and stated in the opening paragraph:

> This is the third annual survey of enrollments and awards *in organized occupational curriculms of at least 1 but less than 4 years' duration* in institutions of higher education. This survey is part of a coordinated series of inquiries by the Office of Education concerned with the Nation's resources of trained manpower.

The questionnaire listed 44 (43 in 1957) engineering-related curriculums and 53 (50 in 1957) non-engineering-

related curriculums, first of "two or more but less than four years" and second of "less than two years but at least one year," and provided spaces for writing in additional curriculums if needed. For each program the institution was asked to report:

(1) Number of graduates July 1, 1957, to June 30, 1958, for men and for women separately.
(2) Type of award—associate's degree, certificate, diploma, or other—given to graduates.
(3) Enrollment on or near October 1, 1958, for first-time students, separately for full-time and part-time students but not with differentiation by sex. (Not asked for in case of curriculums of less than 2 years.)
(4) Total enrollment on or near October 1, 1958, separately for full-time and part-time students, but not with differentiation by sex.

Analysis of Questionnaire Returns

In order to insure complete coverage of recognized institutions of higher education, the Office of Education sent copies of the six-page questionnaire to 1,934 of the institutions listed in Office of Education *Directory—1958–59, Part 3, Higher Education*. Registrars were again asked to return the questionnaire whether or not they had any curriculums meeting the definitions of organized occupational programs as previously quoted, which were contained in the questionnaire. In case they had none, they were asked to indicate the fact by checking in the space provided for that purpose.

The second request was sent on March 17 to 485 institutions which had not replied by that date, and on May 8 a third request went to 136 institutions which still had not replied. On July 9 a fourth request, in the form of a certified letter, was sent to 39 institutions which had not then replied. Finally, on July 29, telegrams were sent to 22 institutions which were thought to be offering the type of programs covered by the survey. (See Table 1.)

The collection of data was closed August 27, 1959, and editing and tabulation of information initiated. At that time no replies had been received from 6 institutions. Since these six institutions comprise 0.3 per cent of those in the country and their total enrollment in 1958 was less than 1 per cent (0.05 per cent) of that in all the Nation's higher institutions, the data may be regarded as virtually complete.

In general, data in Table I indicate that more than one-fourth of the 4-year institutions and practically three-quarters of the 2-year institutions of the country enrolled students in some type of organized occupational curriculum of less than baccalaureate level in 1958. For the first time in this series of studies the number of 2-year institutions exceeded the number of 4-year institutions offering such programs.

TABLE 1

SUMMARY OF QUESTIONNAIRE RETURNS: SURVEY OF ORGANIZED OCCUPATIONAL CURRICULUMS 1958

Item	Total	Institutions	
		4-Year	2-Year
Number of questionnaires sent out Feb. 5, 1959	1,934	1,378	556
Number of questionnaires returned by Aug. 27, 1959	1,928	1,377	551
Percentages of questionnaires returned	99.7	99.9	99.1
Number of questionnaires not returned	6	1	5
Number of institutions with reports on organized occupational curriculums	767	372	395
Percentages of institutions with reports on organized occupational curriculums	39.7	27.0	71.0

TABLE 2

GRADUATES, LISTED BY SEX, FROM ENGINEERING-RELATED AND NON-ENGINEERING-RELATED CURRICULUMS, 1957–58

Type of Curriculum	Number of Schools			Graduates, 1957–58		
	1955–56	1956–57	1957–58	Total	Men	Women
Engineering-Related	202	249	264	12,985	12,912	73
Non-Engineering-Related	620	752	719	30,206	10,616	19,590
All Curriculums	660*	797**	767***	43,191	23,528	19,663
Engineering-Related as Per Cent of Total	30.6	31.2	34.4	30.1	54.9	0.4

* 162 schools offer *both* engineering *and* non-engineering-related curriculums.
** 204 schools offer *both* engineering *and* non-engineering-related curriculums.
*** 216 schools offer *both* engineering *and* non-engineering-related curriculums.

Data Compared on Engineering-Related and Non-Engineering-Related Curriculums

As in previous years, this article contains data which show the importance of organized occupational curriculums in the general system of higher education. This serves to set the stage for the heart of this article, data on engineering technical institute enrollments and graduations.

In order to compare more readily the data on engineering-related programs with other information, Tables 2 and 3 have been prepared.

Tables 2 and 3 contain summaries of graduations (by sex) and of total and first-time enrollments (full-time and part-time) for the 767 institutions which supplied data on organized occupational curriculums, and show some comparisons between the engineering-related and the non-engineering-related curriculums. A word of explanation may be in order in connection with the numbers of schools shown in these tables. Forty-eight institutions reported *only* engineering-related curriculums, 503 reported *only* non-engineering-related curriculums, 216 institutions reported both types of programs, and hence are included under both. This explains why the number of schools with engineering-related programs (264) should not be added to the number of schools with non-engineering-related programs (719) to get the total number of schools.

Table 2 shows some comparisons between the numbers of graduates from engineering-related curriculums and those from non-engineering-related curriculums. As might be anticipated, the graduates

TABLE 3

ENROLLMENTS, TOTAL AND FIRST-TIME, BY FULL-TIME AND PART-TIME, IN ENGINEERING-RELATED AND NON ENGINEERING-RELATED CURRICULUMS, ON OR NEAR OCTOBER 1, 1958

Type of Curriculum	No. of Schools	Total Enrollment		1st-Time Enrollment	
		Full-Time	Part-Time	Full-Time	Part-Time
Engineering-Related	264	41,032	35,080	18,911	9,367
Non-Engineering-Related	719	88,236	42,026	41,029	13,415
All Curriculums	767*	129,268	77,106	59,940	22,782
Engineering-Related as Per Cent of Total	34.4	31.7	45.5	31.5	41.1

* 216 schools offer *both* engineering and non-engineering related curriculums.

from engineering-related curriculums are almost exclusively men (99.4%). On the other hand men constitute only 35.1% of the graduates in the non-engineering-related curriculums, and 54.5% of the total graduates in all the reported curriculums. This compares with last year's percentages of 98.7, 35.5, and 54.3.

In 1956–57 the number of women graduates had increased to 170 from 80 in 1955–56. This year, 1957–58, the number of women graduates is below both previous years, at 73.

The total number of graduates in the engineering-related curriculums is 30.1% of the number of graduates from all curriculums, including 54.9% of all men graduates, and only 0.4% of the women graduates. A comparison with last year's data shows that the percentage of graduations from engineering-related curriculums is up only slightly (0.4%) in comparison to total graduations from organized occupational curriculums, while there is a 3.2% increase in the percentage of institutions which offer engineering-related curriculums compared to all institutions in the survey.

Table 3 shows some comparisons between the engineering-related and the non-engineering-related curriculums in terms of enrollments. Even though the data do not permit the breakdown of the enrollment figures by sex, they do show the breakdown between full-time and part-time, as indicated. From the manpower standpoint it is encouraging to note once again that both total and first-time enrollment of full-time students is considerably larger than that of part-time students both in the engineering-related and the non-engineering-related curriculums. Percentages of full-time to total enrollment are 53.9% for engineering-related, 67.7% for non-engineering-related and 62.6% for all occupational curriculums. Last year's respective percentages of full-time students were 52.5, 65.9, and 60.9. This year, then, the full-time enrollment percentages are all up somewhat, whereas last year they had decreased.

It is well, then, to examine the percentages represented by full-time students of those enrolled for the first time in these curriculums. In this case the percentages are: engineering-related, 67%; non-engineering-related, 75%; and total, 72%. The comparative percentages for 1957 were 57, 71, and 65. Thus the full-time students represent a larger percentage (10%, 4%, 7%) of the first-time as well as of total enrollments in organized occupational curriculums. This is, then, a reversal of what occurred between 1956, and 1957. Evidently these enrollments have not stabilized to the point where trends are apparent in first-time enrollment of full-time students.

The enrollment in engineering-related curriculums as a percentage of the total in occupational curriculums is shown again in the last line of Table 3. Full-time *enrollment* is once more a slightly larger percentage of the totals than the engineering-related *graduates* are of total graduates, and the part-time enrollment in engineering-related programs approaches half of the total, much larger percentages than for either graduates or full-time enrollment. Unlike the other students, those in engineering-related programs, then, are more likely to be part-time students. However, we have already noted that there is a trend toward full-time enrollment in engineering-related programs.

Engineering-Related Curriculums

As indicated in Tables 2 and 3 above, 264 of the 767 responding institutions are conducting engineering-related curriculums. Of this number 80 (82 in 1957) are 4-year institutions and 184 (167 in 1957) are 2-year institutions. Compared to 1957 data this is a decrease of almost 2% of the 4-year colleges and an increase of more than 10% of the 2-year colleges. These institutions are found in 43 states, the District of Columbia, and Puerto Rico. Of the total of 264 institutions reporting engineering-related curriculums, 192 (or about 73%) are publicly supported.

Data on ECPD-Listed and Other Institutions Compared

Basic Table 1 which accompanies this report contains data on total graduates

BASIC TABLE 1

GRADUATES AND ENROLLMENT IN ENGINEERING-RELATED ORGANIZED OCCUPATIONAL CURRICULA, BY STATE AND ECPD-LISTED INSTITUTION, 1958

(Number of graduates and total enrollment are for all curriculums of less than 4 years; enrollment of first-time students is only for curriculums of 2 or more but less than 4 years)

State	Institution	Graduates, July 1, 1957 thru June 30, 1958		Enrollment on or near October 1, 1958			
				Total Students		First-Time Students	
		Men	Women	Full-Time	Part-Time	Full-Time	Part-Time
Cal.	City Col. of San Francisco	69	1	377	106	80	22
Cal.	Cogswell Poly. Col.	24		115		31	
Cal.	Electronic Technical Inst.			280	30	172	
Cal.	Northrop Inst. of Tech.	624		1,469		702	
Conn.	Hillyer Col.	91		296	241	124	58
Conn.	State Tech. Inst.	52		147	777	103	44
D. C.	Cap. Radio Engr. Inst.	200		125	151	110	105
Ga.	Southern Tech. Inst.	223		917		382	
Ill.	Aeronautical Univ.	24		60		40	
Ill.	Devry Tech. Inst.	1,184		1,898	627	386	
Ind.	Lain Tech. Inst.	52		160	99	68	30
Ind.	Purdue Univ.	113		433	1,042	191	
Ind.	Valparaiso Tech. Inst.	144		305		125	
Mass.	Franklin Tech. Inst.	81		239	43	155	43
Mass.	Wentworth Inst.	447		1,399	136	863	59
Mo.	Central Tech. Inst.	206		627	75	48	
N. Y.	Acad. of Aeronautics	309		756	469	355	178
N. Y.	Broome Tech. Community Col.	95	1	397	220	258	65
N. Y.	Mohawk Valley Tech. Inst.	109	1	302	2	292	2
N. Y.	RCA Institutes Inc.	402		1,411	863	210	70
N. Y.	Rochester Inst. Technology	209	7	679	660	244	120
N. Y.	Suny Ag. Tech. Alfred	124		521		248	
N. Y.	Suny Ag. Tech. Canton	86		240		114	
Ohio	Franklin Univ.	31		73	187	19	40
Ohio	Ohio Mechanics Inst.	97		300		176	
Ohio	Sinclair Col.	17		104	79	71	18
Ohio	Univ. of Dayton	84		256	358	104	92
Okla.	Okla. St. U. Agric. App. Sci.	145		451		243	
Oreg.	Oreg. Tech. Inst.	234		713		350	
Pa.	Pa. State Univ.	425	1	1,645		1,017	
Pa.	Spring Garden Inst.	90		165		90	
Tex.	Univ. of Houston	22		449	471		
W. Va.	W. Va. Inst. of Tech.	6		65	9	44	
Wis.	Milwaukee School of Engrg.	375		799	113	227	17
	Total ECPD	6,394	11	18,173	6,758	7,642	963
	Other U. S. Colleges	6,518	62	22,859	28,322	11,269	8,404
	All U. S. Colleges	12,912	73	41,032	35,080	18,911	9,367
	1-year programs data	(1,844)	(2)	(2,247)	(4,041)	(—)	(—)

TABLE 4

GRADUATES, BY SEX, FROM ENGINEERING-RELATED CURRICULUMS IN ECPD LISTED AND OTHER INSTITUTIONS, 1955–56, 1956–57, AND 1957–58

Institution	No. of Schools			Graduates								
				Total			Men			Women		
	1955–56	1956–57	1957–58	1955–56	1956–57	1957–58	1955–56	1956–57	1957–58	1955–56	1956–57	1957–58
ECPD-Listed	31	34	34	5,656	7,294	6,405	5,639	7,272	6,394	17	22	11
Other	171	215*	230	6,086	6,021*	6,580	6,023	5,873*	6,518	63	148*	62
Total	202	249*	264	11,742	13,315*	12,985	11,662	13,145*	12,912	80	170*	73
ECPD-Listed as per cent of Total	15.3	13.7*	12.9	48.3	54.8*	49.3	47.3	55.3*	49.5	21.3	12.9	15.1

* Corrects 1956–57 report to eliminate artisan level programs.

and enrollments for each of 34 institutions[7] in which at least one curriculum was accredited by the Engineers' Council for Professional Development, as of October 1958, a single line of lump-sum totals for the 230 institutions which conduct engineering-related curriculums, which were not so accredited, as well as a line showing total amounts for all U. S. colleges and a line which shows the parts of the total amounts which are graduates and enrollments in 1-year programs.

Table 4 below is a brief summary of the part of Basic Table 1 dealing with graduations. It shows the relationships (among the engineering-related curriculums) between the institutions conducting ECPD-accredited curriculums, and those which have no curriculums so accredited. For comparative purposes, 1956 and 1957 data are also listed.

It is significant that the ECPD-listed institutions continued to constitute an even lower per cent (12.9%) of the total number of *institutions* conducting engineering-related curriculums than in the previous years. They also reported a lesser per cent (49.3%) of *all graduates* from this type of curriculum than reported in 1957, although there was a slight improvement over 1956 data. The ECPD-listed institutions again produced more graduates per institution than the institutions which did not have a curriculum accredited by ECPD. However, the average number of graduates per ECPD-listed institution decreased by 12.5% (from 215 to 188), whereas the average number of graduates from institutions not so listed increased by 3.6% (from 28 to 29).[8]

Table 5 provides a brief summary of the part of Basic Table 1 which deals with enrollments. It shows the relationships (among the engineering-related curriculums) between the two groups of institutions as to enrollments.

As in the previous reports, the ratio of full-time enrollment in the ECPD-listed institutions to the total full-time enrollments in all institutions is not as large as the ratio of graduates shown in Table 4.

A sharp increase was noted in the reports of part-time enrollments in 1957

[7] Tech Rep Division, Philco Corporation, Philadelphia, and Embry-Riddle Aeronautical Institute, Miami, Florida, were not included in this survey even though both had ECPD-accredited curriculums at this time. In the case of the former, it did not meet all five of the criteria listed early in this article; the latter was not listed in *Education Directory, 1958–59, Part 3—Higher Education,* and so was not asked to fill out a questionnaire.

[8] The comparisons to 1957 are based on corrected data as they appear in the tables accompanying the present article. They may not be readily apparent to anyone who reads only the text of the 1957 report.

TABLE 5

ENROLLMENT, TOTAL AND FIRST-TIME, BY FULL-TIME AND PART-TIME, IN ENGINEERING RELATED CURRICULUMS TWO OR MORE BUT LESS THAN FOUR YEARS IN LENGTH IN ECPD LISTED AND OTHER INSTITUTIONS, 1956, 1957, AND 1958

Institution	No. of Schools			Total Enrollment						First-Time Enrollment					
				Full-Time			Part-Time			Full-Time			Part-Time		
	1956	1957	1958	1956	1957	1958	1956	1957	1958	1956	1957	1958	1956	1957	1958
ECPD-Listed	31	34	34	15,186	19,184	18,173	3,839	10,035	6,758	5,608	7,474	7,642	977	2,959	963
Other	171	215*	230	17,312	20,884*	22,859	21,285	26,204*	28,322	9,883	10,531*	11,269	9,669	10,848*	8,404
Total	202	249*	264	32,498	40,068*	41,032	25,124	36,239*	35,080	15,491	18,005*	18,911	10,646	13,807*	9,367
ECPD-Listed as Per cent of Total	15.3	13.7*	12.9	46.8	47.9*	44.3	15.3	27.7*	19.3	36.2	41.5*	40.4	9.2	21.4*	10.3

* Corrects 1957 report to eliminate artisan-level enrollments.

—somewhat less sharp when correction is made to eliminate artisan enrollments. Total part-time enrollment decreased somewhat in 1958. ECPD-listed institutions in 1958 enrolled one of five of all part-time students, compared to one of four in 1957 and one of seven in 1956.

As far as first-time part-time enrollments are concerned, in 1958 ECPD-listed institutions enrolled one of ten of such students compared to one of five in 1957 and one of ten in 1956.

The total full-time enrollment for the ECPD-listed institutions averages 535 per school (564 in 1957, 490 in 1956), while for the other institutions the figure is 99 per school (97 in 1957, 101 in 1956). Although ECPD-listed institutions enroll almost 100 fewer part-time students, 199 as compared to 295, the group of non-ECPD institutions enrolls about the same average of part-time students as it has each year of the survey, 123.

The average non-listed institution enrolls 49 first-time students on a full-time basis; 37, part-time. Each year of this survey both of these averages have been lower than the previous year. The average enrollment of first-time students at ECPD-listed institutions consists of 225 full-time students and 28 part-time students. Part-time enrollees have fluctuated sharply: 32 in 1956, and 87 in 1957. Full-time enrollment averages have mounted each year.

Data on ECPD-Accredited and Other Curriculums Compared

Basic Table 2 which accompanies this report contains data on graduates and enrollments in those curriculums accredited by the ECPD. Under each such curriculum appear the data for the particular institutions which have accreditation in this individual curriculum. The total ECPD data are presented for each curriculum, as well as a lump-sum total for all other institutions which offer this curriculum, and, where appropriate, data on 1-year programs appear in parentheses. This has been done in recognition of the fact that the ECPD no longer accredits 1-year programs and in order to make more realistic comparisons between

BASIC TABLE 2

GRADUATES AND ENROLLMENT IN ENGINEERING-RELATED ORGANIZED OCCUPATIONAL CURRICULUMS BY CURRICULUM AND ECPD-LISTED INSTITUTION, 1958

(Number of graduates and total enrollment are for all curriculums of less than 4 years; data on curriculums of at least 1 year but less than 2 years in length are listed parenthetically following each curriculum; enrollment of first-time students is only for curriculums of 2 or more but less than 4 years)

Curriculum and Institution	Graduates July 1, 1957 June 30, 1958		Enrollment on or near October 1, 1958			
			Total		First-Time Students	
	Men	Women	Full-Time	Part-Time	Full-Time	Part-Time
Aeronautical Curriculums						
Aircraft Design or Drafting						
Cal. Northrop Inst. of Tech.	191	—	691	—	505	—
Ill. Aeronautical Univ.	24	—	60	—	40	—
N. Y. Academy of Aeronautics	98	—	218	208	94	91
Total ECPD	313	—	969	208	639	91
Other Institutions	41	—	163	1,494	82	620
*Total for U. S.	354	—	1,132	1,702	721	711
Aircraft Maintenance						
Cal. Northrop Inst. of Tech.	433	—	778	—	197	—
Mass. Wentworth Inst.	33	—	128	—	74	—
N. Y. Academy of Aeronautics	204	—	321	261	157	87
Total ECPD	670	—	1,227	261	428	87
Other Institutions	259	—	1,186	287	414	120
Total for U. S.	929	—	2,413	548	842	207
(1-year programs data)	(352)	—	(574)	(4)	—	—
Air Cond. Heatg. & Refrig. Curriculum						
Ga. Southern Tech. Inst.	32	—	57	—	26	—
N. Y. S.U.N.Y. A. & T. Alfred	21	—	59	—	24	—
N. Y. S.U.N.Y. A. & T. Canton	18	—	26	—	5	—
Okla. Okla. State University	12	—	23	—	16	—
Tex. University of Houston	6	—	78	57	—	—
Wis. Milwaukee School of Engrg.	44	—	38	3	—	—
Total ECPD	133	—	281	60	71	—
Other Institutions	214	—	442	591	199	146
Total for U. S.	347	—	723	651	270	146
(1-year programs data)	(10)	—	—	(114)	—	—
Architectural & Civil Curriculums						
Architectural Technology						
Cal. City Col. of San Francisco	1	1	12	3	2	1
Ind. Lain Tech. Inst.	15	—	61	29	27	7
Mass. Wentworth Inst.	63	—	165	28	96	14
Total ECPD	79	1	238	60	125	22
Other Institutions	202	2	978	865	431	264
Total for U. S.	281	3	1,216	925	556	286
(1-year programs data)	(39)	—	(28)	(220)	—	—

* There are no 1-year curriculums in this technology.

BASIC TABLE 2—*Continued*

Curriculum and Institution	Graduates July 1, 1957 June 30, 1958		Enrollment on or near October 1, 1958			
			Total		First-Time Students	
	Men	Women	Full-Time	Part-Time	Full-Time	Part-Time
Building Construction						
Cal. City Col. of San Francisco	2	—	12	3	2	1
Ga. Southern Tech. Inst.	31	—	84	—	31	—
Ind. Purdue University	12	—	63	206	39	—
Mass. Wentworth Inst.	44	—	97	—	69	—
Ohio Ohio Mechanics Inst.	19	—	44	—	28	—
Okla. Okla. State University	6	—	18	—	12	—
Total ECPD	114	—	318	209	181	1
Other Institutions	339	4	1,207	649	603	224
Total for U. S.	453	4	1,525	858	784	225
(1-year programs data)	(7)	—	(9)	(36)	—	—
Civil Technology						
Ga. Southern Tech. Inst.	19	—	196	—	96	—
Mass. Franklin Tech. Inst.	9	—	40	7	18	7
Total ECPD	28	—	236	7	114	7
Other Institutions	143	1	605	602	373	152
Total for U. S.	171	1	841	609	487	159
(1-year programs data)	(1)	—	(3)	(12)	—	—
Structural Technology						
Cal. Cogswell Poly. Col.	5	—	21	—	7	—
Oreg. Oreg. Tech. Inst.	9	—	24	—	10	—
Total ECPD	14	—	45	—	17	—
Other Institutions	125	—	307	731	150	199
Total for U. S.	139	—	352	731	167	199
(1-year programs data)	(1)	—	—	(33)	—	—
Surveying						
Oreg. Oreg. Tech. Inst.	19	—	41	—	21	—
Total ECPD	19	—	41	—	21	—
Other Institutions	19	—	177	24	95	10
Total for U. S.	38	—	218	24	116	10
(1-year programs data)	—	—	(3)	(8)	—	—
Chemical Curriculum						
Mass. Franklin Tech. Inst.	5	—	16	2	13	2
N. Y. Broome Tech. Community Col.	5	1	50	—	39	—
N. Y. Rochester Inst. Technology	15	7	92	1	32	—
Ohio Ohio Mechanics Inst.	7	—	23	—	16	—
Total ECPD	32	8	181	3	100	2
Other Institutions	164	22	669	582	358	170
Total for U. S.	196	30	850	585	458	172
(1-year programs data)	(4)	(2)	—	(12)	—	—

BASIC TABLE 2—*Continued*

Curriculum and Institution		Graduates July 1, 1958 June 30, 1958		Enrollment on or near October 1, 1958 Total		First-Time Students	
		Men	Women	Full-Time	Part-Time	Full-Time	Part-Time
Electrical Curriculums							
Electrical, General							
Cal.	City Col. of San Francisco	16	—	85	24	18	5
Conn.	State Tech. Inst.	13	—	52	300	39	13
Ga.	Southern Tech. Inst.	10	—	72	—	41	—
Ind.	Purdue University	6	—	9	44	8	—
Mass.	Wentworth Inst.	42	—	137	7	88	2
N. Y.	Broome Tech. Community Col.	60	—	177	160	108	40
N. Y.	Rochester Inst. Technology	56	—	227	3	74	—
N. Y.	S.U.N.Y. A. & T. Alfred	13	—	106	—	60	—
N. Y.	S.U.N.Y. A. & T. Canton	27	—	87	—	49	—
Ohio	Ohio Mechanics Inst.	34	—	127	—	70	—
Ohio	Univ. of Dayton	6	—	14	30	6	10
Okla.	Okla. State University	15	—	36	—	11	—
Pa.	Pa. State University	157	—	729	—	488	—
Pa.	Spring Garden Inst.	25	—	60	—	30	—
Tex.	University of Houston	2	—	26	47	—	—
W. Va.	W. Va. Inst. of Technology	5	—	38	7	25	—
Wis.	Milwaukee School of Engrg.	121	—	450	56	157	9
Total ECPD		608	—	2,432	678	1,272	79
Other Institutions		584	2	1,864	2,822	946	733
Total for U. S.		1,192	2	4,296	3,500	2,218	812
(1-year programs data)		(142)	—	(52)	(214)	—	—
Electronics, General							
Cal.	City Col. of San Francisco	20	—	108	32	23	6
Cal.	Cogswell Poly. Col.	10	—	50	—	16	—
Cal.	Electronic Technical Inst.	—	—	280	30	172	—
Conn.	Hillyer Col.	61	—	296	155	124	58
D. C.	Cap Radio Engr. Inst.	200	—	125	151	110	105
Ga.	Southern Tech. Inst.	59	—	246	—	105	—
Ill.	Devry Tech. Inst.	941	—	1,770	341	386	—
Ind.	Valparaiso Tech. Inst.	59	—	201	—	125	—
Mass.	Franklin Tech. Inst.	29	—	75	26	47	26
Mass.	Wentworth Inst.	98	—	299	55	187	21
Mo.	Central Tech. Inst.	206	—	627	75	48	—
N. Y.	Mohawk Valley Tech. Inst.	60	—	178	1	170	1
N. Y.	RCA Institutes Inc.	402	—	1,411	863	210	70
Oreg.	Oreg. Tech. Inst.	40	—	165	—	86	—
Pa.	Spring Garden Inst.	25	—	30	—	30	—
Tex.	University of Houston	3	—	161	140	—	—
Wis.	Milwaukee School of Engrg.	57	—	99	22	—	—
Total ECPD		2,270	—	6,121	1,891	1,839	287
Other Institutions		1,084	—	3,855	6,412	1,924	2,383
Total for U. S.		3,354	—	9,976	8,303	3,763	2,670
(1-year programs data)		(648)	—	(1,076)	(1,540)	—	—

BASIC TABLE 2—*Continued*

Curriculum and Institution	Graduates July 1, 1957 June 30, 1958		Enrollment on or near October 1, 1958			
			Total		First-Time Students	
	Men	Women	Full-Time	Part-Time	Full-Time	Part-Time
Radio & TV Technology						
Conn. Hillyer Col.	22	—	—	26	—	—
Ind. Valparaiso Tech. Inst.	85	—	104	—	—	—
N. Y. S.U.N.Y. A. & T. Alfred	23	—	80	—	40	—
Ohio Franklin Univ.	27	—	53	98	13	16
Okla. Okla. State University	25	—	68	—	40	—
Total ECPD	182	—	305	124	93	16
Other Institutions	602	4	1,349	1,963	433	347
Total for U. S.	784	4	1,654	2,087	526	363
(1-year programs data)	(295)	—	(177)	(440)	—	—
Industrial Curriculum						
Ga. Southern Tech. Inst.	23	—	80	—	17	—
Ind. Lain Tech. Inst.	8	—	43	25	20	8
Ind. Purdue University	11	—	16	246	8	—
Mass. Wentworth Inst.	16	—	29	5	14	4
Ohio Univ. of Dayton	6	—	31	41	12	14
Wis. Milwaukee School of Engrg.	87	—	78	5	—	—
Total ECPD	151	—	277	322	71	26
Other Institutions	245	2	875	1,634	568	421
Total for U. S.	396	2	1,152	1,956	639	447
(1-year programs data)	(2)	—	—	(58)	—	—
Mechanical Curriculums						
Diesel Technology						
Mass. Wentworth Inst.	37	—	70	10	40	4
N. Y. S.U.N.Y. A. & T. Alfred	12	—	36	—	18	—
Okla. Okla. State University	11	—	53	—	34	—
Tex. University of Houston	7	—	84	55	—	—
Total ECPD	67	—	243	65	92	4
Other Institutions	96	—	314	66	150	3
**Total for U. S.	163	—	557	131	242	7
Drafting and Machine Design						
Cal. City Col. of San Francisco	10	—	55	16	12	3
Cal. Cogswell Poly. Col.	9	—	44	—	8	—
Conn. State Tech. Inst.	22	—	51	277	32	19
Ind. Purdue University	25	—	106	308	53	—
Mass. Wentworth Inst.	35	—	103	—	60	—
N. Y. S.U.N.Y. A. & T. Canton	27	—	97	—	43	—
Ohio Univ. of Dayton	28	—	86	125	37	24
Okla. Okla. State University	19	—	66	—	43	—
Pa. Pa. State University	268	1	826	—	478	—
Tex. Univ. of Houston	4	—	100	172	—	—
Total ECPD	447	1	1,534	898	766	46
Other Institutions	448	1	1,810	1,733	918	411
Total for U. S.	895	2	3,344	2,631	1,684	457
(1-year programs data)	(54)	—	(73)	(149)	—	—

** There are no 1-year curriculums in this technology.

BASIC TABLE 2—*Continued*

Curriculum and Institution	Graduates July 1, 1957 June 30, 1958		Enrollment on or near October 1, 1958 Total		First-Time Students	
	Men	Women	Full-Time	Part-Time	Full-Time	Part-Time
Gas Turbine Technology						
Ga. Southern Tech. Inst.	12	—	26	—	13	—
Total ECPD	12	—	26	—	13	—
Other Institutions	—	—	—	—	—	—
†Total for U. S.	12	—	26	—	13	—
Mechanical, General						
Cal. City Col. of San Francisco	8	—	44	13	9	2
Ga. Southern Tech. Inst.	37	—	136	—	44	—
Mass. Franklin Tech. Inst.	15	—	28	8	20	8
Mass. Wentworth Inst.	55	—	145	31	82	14
N. Y. Broome Tech. Community Col.	30	—	105	60	60	25
N. Y. Mohawk Valley Tech. Inst.	49	1	124	1	122	1
N. Y. Rochester Inst. of Technology	66	—	212	51	76	—
N. Y. S.U.N.Y. A. & T. Alfred	22	—	106	—	46	—
Ohio Ohio Mechanics Inst.	37	—	106	—	62	—
Ohio Sinclair Col.	8	—	43	43	21	11
Pa. Spring Garden Inst.	15	—	20	—	10	—
Total ECPD	342	1	1,069	207	552	61
Other Institutions	747	1	2,372	3,815	1,116	881
Total for U. S.	1,089	2	3,441	4,022	1,668	942
(1-year programs data)	(24)	—	—	(437)	—	—
Tool and Die Design						
Conn. State Tech. Inst.	17	—	44	200	32	12
Ind. Lain Tech. Inst.	29	—	56	45	21	15
Mass. Wentworth Inst.	24	—	66	—	39	—
Ohio Sinclair Col.	9	—	31	22	20	2
Ohio Univ. of Dayton	8	—	22	32	10	9
Total ECPD	87	—	219	299	122	38
Other Institutions	166	—	373	769	121	301
Total for U. S.	253	—	592	1,068	243	339
(1-year programs data)	(18)	—	—	(70)	—	—
Miscellaneous Curriculums						
Photographic Technology						
N. Y. Rochester Inst. of Technology	51	—	148	—	62	—
Total ECPD	51	—	148	—	62	—
Other Institutions	20	—	78	7	53	3
Total for U. S.‡	71	—	226	7	115	3

† There are no 1-year curriculums in this technology.

BASIC TABLE 2—*Continued*

Curriculum and Institution	Graduates		Enrollment on or near October 1, 1958			
	July 1, 1957 June 30, 1958		Total		First-Time Students	
	Men	Women	Full-Time	Part-Time	Full-Time	Part-Time
Fire Protection Technology						
Okla. Okla. State University	26	—	72	—	19	—
Total ECPD	26	—	72	—	19	—
Other Institutions						
Total for U. S.‡	26	—	72	—	19	—
Total for ECPD Curriculums	5,645	11	15,982	5,292	6,597	767
§Other Curriculums	7,267	62	25,050	29,788	12,314	8,600
All Curriculums	12,912	73	41,032	35,080	18,911	9,367
‖(1-year curriculums totals)	(1,844)	(2)	(2,247)	(4,041)	(—)	(—)

‡ There are no 1-year programs in this technology.

§ These totals are greater than the sum of the totals for "other institutions" shown under each curriculum because they include certain curriculums for which ECPD has accredited no institution.

‖ 1-year curriculums data are included in totals of "all curriculums."

ECPD-listed and other institutions. Such comparisons can be made this time only in a limited way, but provide a basis for more detailed comparisons in later articles in this series.

Since ECPD accredits individual curriculums rather than institutions, the total figures for the ECPD-accredited curriculums in this table do not agree with the totals in Basic Table 1, which presents data covering *all* engineering-related curriculums in an institution which has *any* curriculum accredited. Thus, many institutions have some accredited curriculums and some non-accredited. Basic Table 1 gives a single set of totals for the entire institution, while Basic Table 2 gives data only for the accredited curriculums.

Table 6 presents a brief summary of the part of Basic Table 2 dealing with graduations. It shows the relationship between the two groups of engineering-related curriculums. The total number of 1957–58 engineering-related graduates is the same as shown in Table 4, but a comparison of the ECPD line reported in Table 6 with the corresponding line in Table 4 shows that the number of 1957–58 graduates from ECPD-accredited *curriculums* is close to nine-tenths as large as the number coming from ECPD-listed *institutions*. In previous surveys only about two-thirds of the graduates of ECPD-listed institutions had completed ECPD-accredited curriculums. This indicates that the number of graduates from ECPD-listed institutions who did *not* complete an ECPD-accredited curriculum has dwindled from one of three to one of ten since the survey began. It will also be noted from Table 6 that the per cent of total engineering-related graduates which are represented by graduates from ECPD-accredited curriculums has increased each succeeding year of the survey by more than 5% over the previous year.

Tables 7 and 8 present brief summaries of the part of Basic Table 2 dealing with enrollments. They show relationships between the two groups of engineering-related curriculums. For comparison purposes, 1956 and 1957 data are also given. The total number of students enrolled is the same as shown in Table 5, but as in the case of the graduates, the numbers enrolled in ECPD-accredited curriculums are considerably smaller than the numbers shown in Ta-

TABLE 6

GRADUATES, BY SEX, FROM ECPD-ACCREDITED AND OTHER ENGINEERING-RELATED CURRICULUMS, 1955–56, 1956–57, 1957–58

Curriculum	Graduates, July 1 through June 30								
	Total			Men			Women		
	1955–56	1956–57	1957–58	1955–56	1956–57	1957–58	1955–56	1956–57	1957–58
ECPD-Accredited	3,838	5,019	5,656	3,828	5,005	5,645	10	14	11
Other Engineering-Related	7,904	8,296†	7,329	7,834	8,140†	7,267	70	156**	62
2- or 3-year	*	*	5,483	*	*	5,423	*	*	60
1-year	*	*	1,846	*	*	1,844	*	*	2
Total Engineering-Related	11,742	13,315†	12,985	11,662	13,145†	12,912	80	170**	73
2- or 3-year	9,103	11,151	11,139	9,029	10,989	11,068	74	162	71
1-year	2,639	2,164	1,846	2,633	2,156	1,844	6	8	2
ECPD-Accredited as Per cent of Total Engineering-Related	32.7	37.7†	43.6	32.8	38.1†	43.7	12.5	8.2†	15.1

* Data not available for 1955–56 or 1956–57. ECPD then accredited some 1-year programs.
† Corrects 1956–57 data to eliminate graduates from artisan-level programs.

ble 5 as being enrolled in ECPD-listed institutions. The respective ratios follow. Total enrollment: full-time 88%, part-time 78%; first-time enrollment: full-time 89%, part-time 80%.

Table 7 also presents data on enrollments in 1-year programs in recognition of the fact that ECPD no longer accredits curriculums less than 2 years in length. Thus, the data which can be used to compare enrollments in ECPD and non-ECPD accredited curriculums are more discrete than they would otherwise be. However, only limited comparisons can be made in this report. It is evident that ECPD-accredited curriculums have enrolled an increasingly larger proportion of students with each year of the survey.

TABLE 7

TOTAL ENROLLMENTS, BY FULL-TIME AND PART-TIME, IN ECPD-ACCREDITED AND OTHER ENGINEERING-RELATED CURRICULUMS, ON OR NEAR OCTOBER 1, 1956, 1957, AND 1958

Curriculums	Full-Time Enrollment				Part-Time Enrollment			
	1956	1957	1958		1956	1957	1958	
			1-Year Programs	2- or 3-Year Programs			1-Year Programs	2- or 3-Year Programs
ECPD-Accredited	12,538	15,591	**	15,982	2,861	4,246	**	5,292
Other Engineering-Related	19,960	24,477*	2,247	22,803	22,263	31,993*	4,041	25,747
Total Engineering-Related	32,498	40,068*	2,247	38,785	25,124	36,239*	4,041	31,039
ECPD-Accredited as Per Cent of Total Engineering-Related	38.6	38.9*	**	41.2	11.4	11.7*	**	17.0

* Corrects 1957 data to eliminate enrollees in artisan-level programs.
** Since 1958 ECPD has not accredited 1-year programs.

TABLE 8

FIRST-TIME ENROLLMENTS, BY FULL-TIME AND PART-TIME, IN ECPD-ACCREDITED AND OTHER ENGINEERING-RELATED CURRICULUMS, ON OR NEAR OCTOBER 1, 1956, 1957, AND 1958

Curriculums	Full-Time Enrollment			Part-Time Enrollment		
	1956	1957	1958	1956	1957	1958
ECPD-Accredited	4,440	6,111	6,597	785	2,333	767
Other Engineering-Related	11,051	11,894*	12,314	9,861	11,474*	8,600
Total Engineering-Related	15,491	18,005*	18,911	10,646	13,807*	9,367
ECPD-Accredited as Per Cent of Total Engineering-Related	28.7	33.9*	34.9	7.4	16.9*	8.2

* Corrects 1957 data to eliminate enrollees in artisan-level programs.

(This would be true, too, even if 1-year program enrollments were included.) This is in contrast to enrollments in ECPD-listed institutions compared with other institutions, which showed a decline from the 1957 to the 1958 survey. At the same time, first-time enrollments of part-time students showed a decline both in ECPD-listed institutions and in ECPD-accredited curriculums.

Concluding Comment

The data in this report, and in the more inclusive report of the Office of Education from which it is drawn, constitute "snapshots" of enrollments and graduations in organized occupational curriculums during 1958. Such a "snapshot" has value in and of itself, but its greatest usefulness will undoubtedly be as one of a series of comparable reports from which trends can be determined.

It certainly should be obvious that three points on a curve may suggest a certain trend. This third study has made it possible for us to see changes from 1956 to 1957, and from 1957 to 1958, but whether there is a trend or a temporary fluctuation will need to be determined on the basis of the returns secured in succeeding years. Each year that the study is repeated with comparable reporting the validity of the interpretation will be increased. This study, therefore, will have increasingly important manpower implications.

Mathematical Requirements in Industrial Engineering

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This paper will discuss the topic of mathematical requirements in industrial engineering because I believe that, along with the topic of statistics, it is the most important issue in industrial engineering today. I intend to justify the inclusion of more mathematics in our field first and then briefly indicate which fields of mathematics should be of primary concern to the industrial engineer. I intend to restrict my remarks to the decision making area of industrial engineering, as opposed to the process engineering area, because of my limited experience in this latter portion of our field.

Industrial engineering can now boast of a rather long history, considering that the technology of our times is subject to rapid change. As one looks back over that history, however, he cannot help but obtain the impression that the tools developed by Taylor, Gantt, Emerson, the Gilbreths and their contemporaries were rather crude, even if a major advance in comparison to previous practices. Until the advent of operations research, engineering economy (largely dependent on high school algebra) and statistical quality control (dependent only on the most elementary statistics) were the major areas of industrial engineering in which we used any mathematical or statistical analysis of any importance. Even these were usually taught as cookbook courses with most of the factors being taken from tables rather than obtained by calculation. About the only use of the calculus in years gone by was the derivation of economic lot size formulas. Any other uses of the calculus would consist of special topics of interest to a particular instructor.

When operations research turned its attention to industrial applications, it soon encountered problems which were in the area traditionally the province of industrial engineers. The operations research approach was, however, from the opposite end of the scale. Many of the operations researchers were mathematicians, or statisticians or scientists from various disciplines well versed in the use of mathematics and statistics in analyzing complex problems. Their successes exceeded even their hopes and astounded many of us who had applied cruder approaches to the same problems. It is certainly not a remarkable fact that many of us soon came to feel that we had been remiss in our obligations and should attempt to incorporate some of the operations research ideas into the industrial engineering approach.

Three Groups in I.E.

The result has been interesting. Present industrial engineering curricula may be categorized into three groups. One is the type which is, for all practical purposes, operations research rather than industrial engineering. A second group has continued to teach most of the older techniques, perhaps on a condensed time schedule, and has included some of the basic, elementary results of the operations research approach to date. A third group, now rather small, is still operating untainted by any inclusion of operations research techniques.

The first group, in which operations research is now dominant, has, in my opinion, deviated too far from our normal role in the industrial scheme. The industrial engineering function is an es-

Presented at the Industrial Engineering Summer School of the Industrial Engineering Division of ASEE, June 18–19, 1960, at Purdue University.

sential one in modern manufacturing and one that should be staffed by well qualified and well trained men. It is impossible to teach operations research, whatever the title of the curriculum, in an undergraduate program. So much mathematics is needed that the longer exposure of graduate study is an absolute necessity. If operations research is taught under the guise of industrial engineering, the students will be so oriented towards the mathematical approach that they will not desire to join industrial engineering staffs where the range of potential problems is limited to a department or a plant and where non-mathematical methods are still prevalent for a variety of reasons.

On the other hand, the third group, by failing to recognize the value of the operations research approach at all, is ignoring great potential advantages. Where proven techniques are available to provide more accurate solutions to operating or planning problems, we, as industrial engineers, are doing less than our duty if we fail to inform the students in our charge of better methods of analysis. Thus, I feel that the third group is in the most defenseless position of the three.

The middle group has, in my opinion, followed the most logical road. We, and I include North Carolina State College in this group, try not only to teach the older techniques but to supplement this with newer methods based on the results to date of the operations research approach. Although we, at N. C. State, use one of the texts on elementary operations research methods, we attempt to relate the material to the areas studied earlier with the older techniques. We call our course Industrial Engineering Analysis in an attempt to make clear that we are not interested in turning the students away from our field and into another but instead are attempting to borrow, steal, plagiarize, buy, rent or otherwise obtain from any source whatsoever, techniques that are useful in the industrial engineering area.

Speaking of industrial engineering education in general, it is my opinion that the approach that the second group is attempting has some problems associated with it, the greatest being the lack of stability. Suppose a department now teaching the older techniques only desires to move into the second group where an attempt will be made to apply certain operations research results to industrial engineering. The typical situation will be that most of the staff are older men who find it almost impossible to learn the new techniques themselves. The only way to get the program started is to employ a few new staff members who can teach the new courses and perhaps a few graduate courses as well. After they are in the department, it will soon be obvious to the older staff men that in terms of degrees and publications and from a standpoint of research and graduate teaching activities, they are not as highly regarded at promotion time as are the newer men. Also, some of the older staff may never be sold on the analytical approach, industrial engineers as a class not being excluded from the phenomenon of resistance to change. Hence, discontent may grow with older members leaving for other methods of completing their careers, their replacements coming from the newer generation of industrial engineers. If the department head pushes operations research too hard and if most of the newer men have a disdain for time study, job evaluation, the practical realities of plant layout, etc., the department may easily go all the way to an operations research activity in a span of a few years. This represents abandonment of industrial engineering to graduates of industrial management and like curricula.

It is undoubtedly true that even in the second group, many of the courses offered in the graduate program will have a strong operations research flavor. There is nothing wrong with this. In fact, until operations research came along, there were few areas of industrial engineering where courses of true graduate caliber could be developed. It is also true that much of the research in industrial engineering will tend to be closely allied with operations research as we try to improve the results of previous investigators, whatever their background, and develop models of maximum use to industrial engineers.

Relations with Operations Research

One question that comes up over and over is the relationship between the operations research-oriented industrial engineer and the true, pure operations researcher. Having been involved in about two discussions on this question per week for the last two years, I have gradually formulated an answer in my own mind. It consists of several parts.

1. The industrial engineer has traditional responsibilities, in any given plant, which call for him to restrict his attention to certain operating problems and at the same time exercise continual surveillance over this area. This is true in spite of the fact that he is in a staff position and that he will occasionally be assigned projects outside this assigned area. The operations researcher, on the other hand, is more likely to work exclusively on a project basis.

2. As a consequence of the first point, the industrial engineer must make some recommendation on every problem arising in this area of responsibility, whether a mathematical model can be constructed as a guide or not. On the other hand, the operations researcher is not usually assigned to a project unless there is reasonable hope that a mathematical model can be constructed which will aproximate an optimum to some criteria in the face of realistic restrictions. Once assigned to a problem, the operations researcher is more likely to be unhampered by other duties of a pressing nature.

3. Since the industrial engineer has a responsibility close to the operating level, as compared to the operations researcher, he is more likely to become involved in problems on which recommendations must be made within a time interval so short that neither extensive analysis nor data-gathering are possible.

4. The true operations researcher must always be careful to have an open mind on new problems and be prepared to undertake original mathematical development on any problem which does not fit an existing model. On the other hand, the industrial engineer should not be expected to have the degree of mathematical proficiency to do this. His responsibility should be limited to a thorough understanding of useful, practical models, including how to make minor modifications to fit particular circumstances.

As a consequence of these points, the industrial engineer should complement the operations researcher in a company, and vice versa, rather than be in opposition. The industrial engineer should be able to solve the routine problems arising in his area. When problems arise beyond the scope of models available to him, he should seek the assistance of the operations researcher. I visualize operations research backing up industrial engineering in the same manner that physics backs up electrical engineering. In major projects, of course, operations research may assume broader implications than mathematical and statistical analysis; it may be necessary to involve the full interdisciplinary approach often used in this field.

I have observed two companies which tried to employ operations research personnel as a separate staff when the industrial engineering staff was totally uninformed of the new mathematical approaches we are discussing, and I was impressed by the failure of the operations research effort in both cases. The industrial engineer can hardly be expected to refer problems to the operations research staff if he is unaware that the latter staff can be of assistance. Indeed, he may not only misclassify problems, he may even fail to realize that they exist. The operations research personnel, on the other hand, were not sufficiently acquainted with operating problems to find areas of application of their type of analysis. Industrial engineers and departmental supervisors alike were unwilling to seek aid from the operations research staff because of fear that they would be revealing their lack of competence and because of the distrust of a potential rival for influence with management. The final result of these points was that the problems and those who could solve them seldom met. Educating industrial engineers in the basic operations research methods will, in the long run, in my opinion, be beneficial and stimulating to both fields.

Mathematics in the Undergraduate Program

Engineering has traditionally employed mathematics which consists primarily of trigonometry, analytical geometry, college algebra and the differential and integral calculus. This amount of mathematics has long been considered to be the absolute minimum for engineering work. Of late years, most engineering curricula have been modified to add differential equations to this minimum list. For modern industrial engineering this is not enough, although it is still essential. In contrast to our sister engineering fields, most of our new techniques do not rely on the calculus approach but rather emanate from the field of finite mathematics and/or statistics. We may define finite mathematics as consisting of set theory, symbolic logic, probability theory, matrix algebra and the calculus of finite differences.

As an example of the necessity for finite mathematics, we may consider queuing theory. While the basic queuing equations can be obtained from a differential equations approach, a full understanding of the subject requires its study as a topic of probability theory, specifically a stochastic process and even more specifically, a Markov process. The best starting point for this study is set theory, for probability notions can best be understood as phenomena occurring in sample spaces. To thoroughly understand the Markov process, a knowledge of matrix algebra is necessary to be able to efficiently treat the transition probabilities. With this approach to queuing theory, a thorough understanding can be obtained of the basic phenomena even though in an undergraduate course one cannot hope to proceed past the elementary queuing models.

A second example is linear programming. If one is to make full use of linear programming, he must be introduced to the theory as well as the various algorithms. Specifically, the dual theorems and the revised simplex method should be covered and these are almost beyond understanding unless the presentation from the beginning has been in terms of matrix algebra.

I am becoming increasingly convinced that the calculus of finite differences is a subject which we must fit into our curriculum. It is now necessary to devote several sessions to the concepts of differencing functions and solving difference equations in our senior Industrial Engineering Analysis course. This will become increasingly important in inventory control, replacement theory and queuing theory, as well as in other areas, as research extends these areas.

Although I do not believe that state institutions, as a class, need apologize in any respect for the quality of engineering education they provide, it seems to be true that private schools have been able to proceed fastest in the matter of insisting that the entering student be already provided with a large share of his mathematics in high school. The state universities in my area of the country are finally moving on this and it will result in much more effective engineering education. With differential equations completed within the sophomore year instead of during the junior year, greater flexibility of program planning is possible. Also, strong students will be able to proceed further in mathematics during their undergraduate years.

In summary, then, I would recommend mathematics through differential equations plus some work in the field of finite mathematics. In the finite mathematics course I would recommend three areas of emphasis: 1. set theory, leading up to an introduction to symbolic logic and probability theory from the standpoint of sample spaces; 2. matrix algebra including an introduction to vector spaces; 3. the calculus of finite differences, including the solution of the simpler types of difference equations. The contrast throughout this third area should be with the corresponding problems as they occur with continuous functions.

This material need not necessarily be a separate course and it may even be included as a part of the industrial engineering work. Advanced calculus would certainly be desirable to give the student a more complete background in the calculus area, but there are few four-year curricula which would not be thrown out

of balance by such an emphasis on mathematics. The better students should be urged to take work in this area as a prelude to graduate study. The question which one should ask about the mathematics content of the curriculum is: Does this curriculum provide enough competence in mathematics so that the graduate will be able to read the literature in his field, particularly the *Journal of the American Institute of Industrial Engineers*?

Math in Graduate Programs

The requirements of mathematics in the typical graduate program in industrial engineering is another matter. We must first recognize that the graduate student may, in his specialized study, not wish to continue in the mathematical analysis field but may prefer a program in personnel relations or process engineering or work measurement. If so, he may be able to devise excellent programs in which there are no courses in mathematics. On the other hand, if he is interested in the decision-making area or in operation planning, there is no limit to the extent of mathematics that may be justified. With the exception of courses specifically designed for graduate students in specific fields, he will find all advanced mathematics courses of interest. General courses such as Advanced Calculus, the Calculus of Variations, and Complex Variable Theory, for example, will be useful in many areas. If the graduate student is planning a career in research and teaching, several courses in pure mathematics, such as Topology, Abstract Algebra or Analysis would have my heartiest recommendation. There is, then, no upper bound on the mathematical level that can be justified, although the final program should contain reasonable balance.

I will close with one final note. We must find, working cooperatively with our departments of mathematics and perhaps even with our public school systems, methods of achieving greater comprehension of mathematics. In my institution, and I suspect in yours, the vast majority of students at, say, the senior level, have achieved considerable ability to compute from equations and considerable ability to interpret equations *once they have been derived*, but little real mathematical sense. In my senior course, the biggest achievement was in this area, in my opinion. For example, the importance of the continuity assumptions in the calculus finally became clear to the students when studying the differencing of finite functions. By using probability notions, such as the simple one of expectation, in several different areas they finally began to think, to some extent, in probability terms. By the end of the course, many of them were beginning to exhibit an ability to formulate a problem mathematically and derive their own equations. The progress in this direction was significant but not as large as I hope to be able to induce in the future. When I think of the possibilities of the course if I had started with this degree of mathematical thinking instead of almost pure problem-to-formula matching, I am considerably disturbed, however. Somewhere along the line, our training in mathematics and the engineering sciences must be altered, perhaps by increasing motivation through more challenging problems, that will result in the student realizing that mathematics is, after all, a language and is not necessarily more difficult or abstract than the native language of another country.

ANNUAL MEETING, UNIVERSITY OF KENTUCKY
JUNE 26–30

Teacher Preparation

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We hear much these days of the urgency of, and necessity for, increased productivity in all phases of our industrial activity. The already defined problems of the next decade facing our educational institutions, their administrators, and the teaching staffs provide as much, if not more, demand for improved productivity in the educational sphere. I speak here not of numbers alone, but of the quality of the task to be accomplished by what has become the largest occupational segment of our population.

The first and to many the most important conclusion of the Conservation of Human Resources Project in their studies of the ineffective soldier was the extent to which the present manpower situation is determined by the past. The actions we take—or do not take—today will materially affect the state of our nation's scientific and professional manpower a decade or two from now. Moreover, the more highly specialized our society becomes, the more dependent it is on highly educated personnel.

In an educated society such as ours, education is capital investment, for on it rests the effectiveness and productivity of most other capital investment. Such capital investment cannot be postponed; time lost by postponement means educated people and their contributions lost forever.

But the cornerstone underlying the entire investment is the teacher. All the available statistics point to severe problems ahead for the nation in providing adequately qualified teachers in sufficient numbers at any point in the foreseeable future. Findings of the Research Division of the National Education Association, published in mid-1959, indicated a need for approximately 5,300 new full-time university, college and junior college teachers in engineering, mathematics and the physical sciences for the 1960–61 school year. Of this number, 3,000 represent replacements, estimated at 6%, while 2,300 are new additions to the teaching field. Over the eleven year span, from 1959 to 1970, the report shows that over 66,000 new teachers, replacements and additions in these three fields alone will be needed. Where must they come from? Largely from the classes that you are teaching today, and from the classes that will be taught by you and your present students in the next several years. I believe we can all appreciate the effects that our actions today will have on our tomorrows. The problem of proper utilization of professional personnel and the provision of the means for developing every element of potential in an individual are surely as important in the university scene as they are to us in industry.

The Terms

Every good engineering analysis begins with a definition of the problem and of terms. Before we can approach the problem of teacher preparation, I believe we must have some understanding of what a teacher is and does. One of my colleagues defines a teacher as an opportunist—hastening to add that this is an individual who creates the opportunity to learn. Though the teacher plays the principal role in imparting knowledge and nearly as great a role in fostering

Presented at the 22nd Annual Meeting, Rocky Mountain Section, ASEE, United States Air Force Academy, April 30, 1960.

comprehension, his role becomes less apparent, though more difficult, as the educational objectives rise in order to application, analysis, synthesis, and evaluation. These higher levels require a more active participation on the part of the learner, if the objectives are to be met. The teacher must provide the situations within which the student will work, but the student assumes an increasing responsibility for his educational achievement. Thus, it is not alone sufficient that the teacher possess the subject knowledge; he must also be able to create a favorable environment and student attitudes, within the framework of which assimilation of the knowledge and the ability to put it to use can grow.

I very much like the characterization of a teacher drawn by Professor Gilbert Highet in *The Art of Teaching*. In addition to a knowledge of the subject, Professor Highet says that the teacher must have a liking for his subject which is with enthusiasm transferred to the student. Furthermore, he deems it necessary that, for effective teaching, the teacher must like the students, and be genuinely interested in them to the extent of knowing their individual characteristics. Only in this manner can he create a learning climate which is appropriate for each. We have recently, in our Company education classes, experimented with some group dynamic theories which were designed to provide the instructors with a better understanding of their classes. Though the instructors, men with purely technical backgrounds, were dubious at first, they soon admitted that the findings had provided them with insights into individual problem situations from which they were able to improve the learning of these class members.

Finally, Professor Highet says that a good teacher is an individual of exceptionally wide and lively intellectual interests. Teachers must see more, think more, and understand more than the average man or woman in our society. I call this the requirement for an active mind, a mind which will continue to grow. More of this in a moment.

Separate from the qualities of a good teacher, Professor Highet lists three necessary abilities which are, in relation to what I have said earlier, almost self-apparent. A good teacher must have a creative memory, to be able to demonstrate the organic links between apparently remote facts; he must be a determined person, for teaching requires a determination to create a favorable learning situation; thirdly, he must be genuinely kind. Learning cannot occur in an atmosphere of dislike or suspicion from whatever source.

I'm sure that we have given ample consideration to the intellectual abilities and characteristics of an individual when we invest him with the responsibilities of teaching; I wonder, though, if we are giving due consideration to the development of these other qualities and abilities which are so necessary to a favorable learning environment.

Changing Scene

If there is one thing we may count on for the future in engineering, that one thing is change. In fact, change has come to be looked upon as the norm, and the absence of change is cause for alarm. The changing technologies, the changing applications of the older technologies, and, in fact, the changing role of the engineer in modern society, have all placed greater demands upon the educational process through which his professional competence and stature are attained, and with resulting changes in that educational process.

It used to be considered that a man could study for 4 or 5 years in an engineering college, graduate with the assurance that he would find his work much the same as he had been taught in school, and furthermore that it would remain pretty much that way during most of his career. Now, it is pretty well recognized that the 4 college years are but the introduction to the 40 years of an engineering career. Dean McEachron of Case Institute has graphically illustrated this point in tracing the relationships between science and engineering during the past century.

Though 50 years elapsed between the discovery by Michael Faraday of the basic laws of motor and generator behavior and their practical application by

Thomas A. Edison, the lead time between scientific discovery and engineering application was in our time reduced to the 2-year span between the announcement of artificial diamonds from the General Electric Research Laboratory and their production-line manufacture in an operating department. Even more recently, a missile guidance system was engineered with the assumption that one essential component not then available could and would be proven from scientific discovery before completion. More and more the engineer has found it necessary to maintain a close coupling with the scientist in order that the newest scientific discoveries be made useful to man.

Recognition of these facts and trends made imperative a decision on the part of industry that continued technical education is an essential element of engineering work. Last year's technology has been proven inadequate for today's work. The young engineering student must be prepared for a professional way of life in which continued learning is integral with his ability to contribute. Otherwise, he will become obsolete along with his early designs.

Though engineering educators are concerned with the preparation of teachers for academic institutions, we should not lose sight of the fact that teachers are to be found all throughout the realm of engineering work. Much of the continued learning will take place in industry, in courses of study sponsored by the professional societies, in working relationships, and on the job. In the broadest sense, then, a great amount of teacher preparation begins right in the classroom. Not only are you presently preparing teachers for your classrooms, but in the example you set today and the attitudes and habits you help to develop, you will be responsible for the quality of the nonacademic teaching that the others will do in the fulfillment of that phase of their professional responsibility.

Keeping Abreast

This climate in the industrial sphere has two important and related implications for the engineering teacher. First, he, himself, has no less an obligation for updating, for continual self-development. No longer should one contemplate retiring to the teaching profession for a life of leisurely pace. One has to run hard to even stand still in these times. By keeping his class discussions and lectures in a current context, he sets a climate for the students in which they will develop the same necessary attitudes and habits. There are several ways in which the teacher can remain abreast in his field and as an engineer. One, of course, is through the growing amount of sponsored research that is found on university campuses today. Another is the opportunity that many have for industrial consulting work. You and I are aware of the pitfalls to be avoided in both of these activities; however, if the individual recognizes and remains conscious of the reasons behind such work, he is more likely to engage in those activities which are a proper part of his own development plan. There is the opportunity for summer industrial work, an activity which the Relations with Industry Division of ASEE has fostered for several years. You will recall the fourth annual tabulation of such opportunities in the January, 1960 issue of the *Journal of Engineering Education*.

One avenue for development of both teacher and teaching which I have long felt underdeveloped is that of a mechanism for exchange of personnel between industry and the colleges. It is true that many faculty members spend sabbatical leaves in industrial work, but I am thinking more in terms of one year or two at a stretch or perhaps a regular alternation. Moreover, I feel certain that there are a number of outstanding men in industry who would welcome the opportunity to enter teaching for a similar period in order to make available their more recently acquired knowledge and experience for the benefit of the educational process. I feel sure that better ways could be found to effect such exchanges to the mutual advantage of both parties.

Keeping abreast will contribute to the solution in a second problem area of responsibility for the teacher—that of what is important to teach in his courses and the college curricula. This problem has become acute in recent years because of

the increasing rate of technological change. The colleges have recognized that they must be preparing a man not solely for his first job, but also for work that does not yet exist and cannot yet be clearly defined. At the same time, the scope of an engineer's assignment has increased; the magnitude and extent of the responsibilities in today's projects are vastly greater than heretofore. Should we continue to maintain the traditional concentration in separate engineering disciplines and the further specialization within the disciplines?

We have noted earlier that much of the man's later education and updating are *his* responsibility. But to do this, he must have a sound foundation on which to build. The design and teaching of a college curriculum which is adequate preparation for a full career under these conditions requires a breadth of view and understanding. One way to assure a balance is that of changing teacher assignments—rotating teachers not only within their own chosen field, but through all department courses and perhaps even across departmental lines. One thing is clear in practice—real engineering problems do not come neatly packaged like the course descriptions in a college catalog. The boy who says, "I am an electronic engineer: I'm only concerned with the circuit design" is in for a big disappointment when he sees his equipment fail due to overheating, or fly apart in vibration and shock test. Or again, it is equally important that the aircraft armament and control systems designer understand the problems of supplying electric power from a jet engine as prime mover through a rotating electrical machine (a dirty word in the eyes of some today).

Clifton Fadiman pointed out in a recent article on education in the "Saturday Review" that certain subjects were outstanding in their importance because of their generative power—the ability and characteristic they have for providing a basis for further knowledge. It is oftentimes easy to identify such generative subjects individually, but to choose such subjects in combination, and relate them in their order of importance, requires far more than many years of teaching in one subject area. No longer is there a place in the curriculum for Professor Jones's course in reciprocating engine design simply because Professor Jones has always taught that course to the senior class.

There are real contributions to be made in the area of synthesis of studies for engineering college curricula. The need certainly exists to further clarify what the requirements are for a sound foundation to an engineering career. And, no doubt, those requirements are themselves in a state of flux. One thing seems certain—the schools will, to an increasing extent, concentrate on the fundamentals, mathematics and the basic and engineering sciences, leaving the specialized technologies and state of the art for industry to teach. There is ample evidence of healthy experimentation in a number of colleges, as we see engineering physics and engineering science curricula evolved. Yet, in this trend, there is still a real danger that we will produce scientists and not engineers. Let us not forget the distinction: "Scientists make it known—Engineers make it work."

New Problems

I'd like to talk for a moment about two new problem areas that I believe will confront teachers in the immediate years ahead. I believe there will be recognition of the need for increased planning in the educational world, not merely for expanded physical plant, but in the educational process as well, planning that begins with a formulation of objectives and goals for the institution, for the department, for the teacher and for the student. I think it quite appropriate that different schools might have different objectives for their education, which might vary, for example, with their origins and heritage, their geographic location, and the market for their graduates. It would be highly advantageous for all concerned to have these objectives in writing for all to be guided by in their decisions, students as well as teacher and administrator.

Equally important to the Young Engineering Teacher is a plan for his individual development. Experience in

manpower development has shown the value of actual work assignments in individual development; what courses he shall teach, what industrial work experience he needs, to whom shall he look for guidance and counsel. Educational institutions will, I am sure, find it necessary in the same manner as industry, to plan its manpower development carefully, to ensure the development of all available potential, and to fully capitalize on it.

In the actual teaching, I believe each course should have stated goals of accomplishment by which both the students and the teacher are measured. Peter Drucker, a critical observer of our contemporary scene, in his book, *Landmarks of Tomorrow*, has commented on this point. After observing that education has traditionally, from an economic viewpoint, been classed as a luxury trade, one in which skill is not recognized in the monetary rewards, Mr. Drucker writes:

"Teachers have differed from all other traditional luxury trades in one essential respect: there have been no performance standards. The reason is simple enough. The performance of a goldsmith or of a fur worker can be easily measured. But, how is a teacher's performance to be measured? When—now or twenty years later? By whom? And what constitutes good performance? Because we have never been able to answer these questions, there is no other field where mediocrity and incompetence are so patiently accepted, especially in secondary and higher education. The good teacher has always and everywhere been badly underpaid. But, the poor teacher, especially in higher education, is probably not only overpaid; he may cause loss far beyond his 'direct cost,' i.e., his salary. But how to tell the two apart, except by purely arbitrary, personal judgment?"

He further observes that we need to know more about the teaching process than we now know, nor can we depend on high salaries alone to bring the most qualified people into teaching and keep them there. We shall need objective performance appraisals for teachers in their teaching work in the same sense as those measures we have developed for engineers, executives, and other professionals.

These remarks have brought us into the area of measurements, the second of these new areas. For obviously the purpose of setting goals is to be able to measure, and to determine progress and the extent to which goals are or are not met. To achieve this better understanding of the educational process which Mr. Drucker deems essential, meaningful and reliable educational research will be required. Higher education (with the possible exception of the education field itself) has in the past stood aloof from this activity. The problem of future teacher supply and student enrollment alone is ample reason for abandoning that earlier stand. We shall need to know the effects of advanced degree study as a prerequisite for teaching, of class size, of personal contact vs. television images, the value of teaching machines, and others, on the educational process and the quality of the graduate. It is good to see reports in our society *Journal* of work already in progress, but a great deal more will be needed in years to come. It will require understanding and the cooperative participation of the engineering teachers themselves. The potential gains we, as a nation, cannot afford to pass by.

Industry's Contribution

You are interested, I know, to learn where there are opportunities for industry to contribute to this endeavor. I believe that close contacts between industry and the colleges through the channels of sponsored research, professional and technical societies, the increased industrial support of graduate study programs, and meetings such as this one today, will provide a feedback of the needs of the engineering graduate in his work and the demands of that work on the knowledge acquired through formal preparation. Important to the teacher will be the assessment by industry of the intellectual abilities which he has developed in the graduates, and whether these graduates have, in fact, the sound foundation for their continued self-development that is so essential. You will recognize the limitations imposed by proprietary requirements; but, in the

main, industry is vitally interested in assuring itself and the nation of a continued flow of well educated young men and women. To that end, it will continue to make available information on new technologies, or advances which require changed emphasis in the educational program. The teachers must maintain an alertness to these developments so that they can be effectively integrated while maintaining a sound curriculum. We will certainly want to maintain strong channels of communication that we may continue to exchange viewpoints freely in full recognition of our mutual interests and interdependence.

I have already mentioned the media through which engineering teachers can acquire experience in industry, and suggested a search for a new mechanism to provide an increased exchange of personnel.

Finally, I hope it is evident that the more stable elements of industry recognize full well their obligations and exercise self-imposed restraints with regard to men who have an inclination to teach. The fable of killing the goose that lays the golden eggs could well become reality were the supply of new teachers for engineering faculties to be shut off. One vital portion of that supply is from industry—the man who has through industrial experience demonstrated his intellectual capabilities and develops a desire to teach. We, in our organization, can point with pride to the men we have "promoted" in this fashion. They number at least three Deans of Engineering Schools, including the current President of the Society, Dean Teare, several department heads, and uncounted others. Other industrial organizations can do likewise. This is healthy, and we hope it will continue in this fashion.

If I can leave one thought with you, that one thought is that teacher preparation is a continuing thing. Teaching requires a sustained intellectual activity to an extent greater than any other profession. Preparation begins at least as early as in your classrooms and will continue throughout an entire professional career in industry as well as on a campus. We are all teachers in some sense—whether as parents, by actual position or by implicit means in other relationships. Let's not lose sight of the intangible but human values that comprise this entity we call a teacher.

FORD GRANTS FOR GRADUATE EDUCATION

A series of grants to strengthen and expand engineering education at the doctoral level in Southern universities has been announced by the Ford Foundation. They total $3,110,000 and will go to:

Georgia Institute of Technology	$680,000
University of Florida	695,000
North Carolina State College	760,000
University of Texas	975,000

The grants are aimed particularly at upgrading and expanding engineering education at the doctoral level, since the doctor's degree is considered essential for able engineering teachers and advanced research personnel. The four institutions receiving these grants award nearly all the doctoral degrees in engineering in the South.

The funds will be used to hire new faculty members who are capable of teaching doctoral courses and guiding graduate students working on their doctoral theses; to aid the professional development of present faculty members, so that they may be better prepared for teaching at the doctoral level; to expand and improve graduate enrollment; to set up a general fund for the use of the institutions in developing doctoral education in engineering; and to stimulate stronger and more lasting support for the faculty and graduate-student development at the institutions.

What's Going on in ASEE

A Narration of Major Actions of the Executive Board at its February 1961 Meeting

W. Leighton Collins, Secretary, ASEE

The budget for 1961–62 and a revision of the dues structure for institutional members occupied much of the time at the February 8 meeting of the Executive Board. Dues for such members have not changed since 1946. Improved services and the increased cost of everything is making an increase necessary. Also, the rate of growth of membership is inadequate to meet the mounting costs.

The following newly elected Industrial Members are welcomed into the Society:

Allegheny Ludlum Steel Co.
American Electric Power Service Corp.
Buffalo Forge Co.
Burroughs Corp.
Continental Can Co.
Gulf Research and Development Co.
Joy Manufacturing Co.
Koppers Co.
Maytag Co.
Pennsylvania Power and Light Co.
Swift and Co.
Westinghouse Air Brake Co.
West Virginia Pulp and Paper Co.

The "glad hand" also is extended to Merrimack College and San Fernando Valley State College, newly elected Affiliate Members and to the American Road Builders Association as an Associate Member. A decision was made to invite junior colleges and small liberal arts colleges with strong pre-engineering courses to join ASEE and participate in Section and Annual Meetings. Deans of engineering and Section officers are asked to cooperate.

What started out to be the best of the past six years for advertising in the *Journal* is turning out to be "just another year." At first, the amount of advertising was about 15% ahead of last year, then it was about even, and for the spring months it looks as though it will be down 15 to 20%. Next year, there will be a slight regrouping of material in the *Journal* to increase the preferable location of advertising.

The number of new members elected this year still lags behind the average for the past five years, and the magic number of 10,000 individual members might not be realized this year. Everyone is urged to cooperate with the institutional representatives working on membership.

ECRC reports that its biennial *Research Review* will be available in May. The cost is $4.00 per copy. An order form is on page xv; order your copy now.

A preliminary report on Divisional publications by Vice President Hall revealed up-coming plans for coordinating publications, their appearances, and costs —identifying all of them with ASEE and with each other.

The offer of the Westinghouse Educational Foundation to renew the George Westinghouse Teaching Award for the period 1962–64, inclusive, was approved. Appreciation also was expressed to the Foundation for financing the Invitational Conference on Faculty Utilization and making available its facilities for holding the conference.

The *Road to Graduate School* is proving to be a "best seller," even though "its cost is free." From one magazine publishing a short paragraph based on a news release, almost 1,000 individual orders from men in industry have been received! But Foundation support for printing and distribution of *The Road* and *Teaching Tomorrow's Engineers* is no longer available. Additional funds will need to be sought.

(*Continued on page 761*)

LIST OF PUBLICATIONS

American Society for Engineering Education

University of Illinois — **Urbana, Illinois**

1. Engineering Faculty Recruitment, Development, and Utilization	$ 0.25
2. Engineering Enrollment and Faculty Requirement, 1957–67	.25
3. Engineering and Scientific Manpower Problems and an Annotated Bibliography	.25
4. Report on Evaluation of Engineering Education	.25
5. Report on the Engineering Sciences	.25
6. General Education in Engineering	.25
7. General Education In Engineering Curricula: Old Issues and New Developments	.25
8. Manual of Graduate Study in Engineering	.25
9. Facilities and Opportunities for Graduate Study in Engineering	.25
10. The Road to Graduate School	free
11. Teaching Tomorrow's Engineers	free
12. Improvement of Engineering Teaching	.25
13. Educational Aids in Engineering	1.00
14. Report of Committee on Engineering Education After the War	.25
15. ECRC Research Review, 1961 (Old issues $2.00 per copy)	4.00
16. A Survey of Research in the Nation's Engineering Colleges: Capabilities and Potentialities—July 1956 to June 1957	.25
17. An Engineer's Library-Guide to the Profession	.25
18. Salaries and Income of Engineering Teachers (Joint Study of Engineers' Joint Council and ASEE)	.25
19. Recruiting Practices and Procedures	.10
20. The Engineering Technician	.25
21. Problems and Potentialities of the Technical Institute	.25
22. The Technical Institute in America (Order from McGraw-Hill Book Co.)	
23. Report on Engineering Education Exchange Mission to the Soviet Union	.25
24. Dynamic Influence in Engineering Education A brochure explaining Individual Membership	free
25. Let me Introduce You to the ASEE A brochure explaining Industrial Membership	free
26. Do You Need More High Quality Engineers? A brochure explaining ASEE's Industrial Fellowship Plan	free
27. Journal of Engineering Education Yearly subscription	10.00
Single Copies, Except Yearbook-Directory	1.25
Yearbook-Directory	7.50
28. Research Relations Between Engineering Educational Institutions and Industrial Organizations (Purchase from Superintendent of Documents, Washington 25, D. C., 25¢ each.)	

Notes—Quantity prices submitted on request.

An additional charge of 10¢ per publication is made for foreign shipments.

College and University Short Courses and Conferences, 1961

Advanced Petroleum Reservoir Engineering

Date: July 10–21, 1961 (Frequency-Annually)
Objective: To present today's practice with new and advanced reservoir concepts in petroleum reservoir engineering
For: Petroleum engineers and teachers of petroleum engineering
Fee: Registration—$225.00 per person, excluding room and board
Address: Petroleum Engineering Department, Attention Dr. Wieland, The University of Tulsa, Tulsa 4, Oklahoma

American Society of Agricultural Engineers

Date: Oct. 18–19 & 20, 1961
Objective: Annual Regional Meeting to foster ASAE
For: Educators, Business Firms, Farmers, Federal Agencies & Students who are interested in Agricultural Engineering Practices
Limitations: Five NW States and Three NW Canadian Provinces
Fee: Approximately $10.00 to $15.00
Address: Boise Hotel, Boise, Idaho

Beryllium Conference

Date: Tentatively scheduled for September 7–8, 1961
Objective: Presentation of current information on research and progress in beryllium metallurgy
For: Anyone interested
Fee: $25.00
Address: M. Berk, New York University, College of Engineering, New York 53, N. Y.

Ceramics: Application of Dislocation Theory

Date: July 31–August 11, 1961
Objective: Present the background of dislocation theory and its direct applications to ceramic materials to a group of qualified engineering faculty members
For: College teachers in the fields of ceramics, metallurgy, and materials science
Fee: NSF will pay $180.00 stipend per participant plus travel allowance to a maximum of $75.00
Address: Professor Richard M. Fulrath, 268B Hearst Mining Building, University of California, Berkeley 4, California

Chemical Physics of Non Metallic Crystals

Date: August 28–September 1, 1961
Objective: Conference for researchers in field
Address: Technological Institute, Northwestern University

Coatings Course for Architects, Painting Contractors and Maintenance Engineers

Date: 10–14 July, 1961 (Annually)
Objective: To introduce enrollees to latest developments in coatings, their properties and applications
For: Architects, painting contractors and maintenance engineers
Limitations: 60 students
Fee: $25.00
Address: Dr. Wouter Bosch, Dept. of Chem. Eng. & Chem., M.S.M., Rolla, Mo.

Communication Theory and Information Handling

Date: June 19–30, 1961
Objective: Coordinated presentation of modern development in the area of topic
For: Any technically qualified person, whether from education or industry
Fee: $250.00 except that educators are entitled to a special $125.00 institutional rate on request
Address: Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia 4, Pennsylvania

Electric Meter School

Date: October, 1961
For: Young engineers and meter men
Fee: $9.00
Address: College of Engineering, Univ. of Arkansas

Electrical Contacts

Date: June 11–16, 1961
Objective: To offer theory and practice in electrical contacts including static contacts, sliding contacts, commutation, arcs, contact materials and contamination
For: Practicing engineers, physicists and research scientists; both new and old in the field
Fee: $90.00

Address: Engineering Seminars, Conference Center, The Pennsylvania State University, University Park, Pa.

Electron Microscopy of Inorganic Materials

Date: June 19–31, 1961; once only
Objective: To teach basic ideas involved in transmission electron microscopy
For: Educators and others working with inorganic materials.
Fee: $250.00; no stipend
Address: Engineering and Sciences Extension, University of California, Berkeley 4, California

Engineering Sciences, Summer Institute

Date: June 26–August 4, 1961
Objective: Strengthen engineering education in colleges not offering an engineering degree
For: Physics and engineering teachers in pre-engineering jr. colleges and 3–2 liberal arts colleges
Fee: NSF stipend, dependency, and travel allowance—$25.00 per credit. For others—no registration fee
Address: Prof. C. H. Coder, Director, Summer Institute in The Engineering Sciences, Bucknell University, Lewisburg, Pa.

Heat Transfer and Fluid Mechanics Institute

Date: June 19, 20, 21
Objective: Technical and scientific advances in fluid mech., heat transfer
For: Interested engineers and students
Fee: $7.50 for membership and the proceedings; $2.00 for students
Address: Dr. R. C. Binder, School of Engineering, University of Southern California, Los Angeles 7, Calif.

Highway Engineering Conference, 7th Annual

Date: May 4 and 5, 1961
Objective: To bring together members of the groups interested in design and construction of highways
For: All interested in highways
Fee: $5.00 (includes banquet)
Address: Civil Engineering Department, New Mexico State University, University Park, New Mexico

Hydraulics Division Conference, ASCE

Date: August 16–18, 1961
Objective: Discussion of technical problems in hydraulics (ground and surface water hydrology, hydrometeorology, hydraulics structures, sedimentation and hydromechanics)
For: Members and guests
Fee: To be established
Address: Prof. J. M. Robertson, Department of Theoretical and Applied Mechanics, University of Illinois, Urbana, Illinois

Industrial Applications of Radioactive Isotopes

Date: July 17 to August 11, 1961, University of Virginia, Charlottesville, Va.
Objective: To encourage the usage of radioisotopes
For: Interested persons in industry, research and teaching
Limitations: Regional
Fee: $150.00
Address: Dr. James W. Cole, Jr., Box 3697, University Station, Charlottesville, Va.

Instrumentation Conference, Tenth Annual

Date: November 3–4, 1961
Objective: To keep people concerned abreast of the developments in the field of Instrumentation and its applications to process control
For: Industry representatives and engineering educators and practicing engineers
Fee: $6.00
Address: School of Engineering, Louisiana Polytechnic Institute, Box 255, Tech Station, Ruston, Louisiana

International Design Conference

Date: June, 1961
Objective: To stimulate and revitalize the attendees so that they can more effectively serve in these fields
For: Designers, architects, artists, writers, scientists, engineers musicians, educators, etc.
Address: Aspen, Colorado

International Symposium on Gas Chromatography

Date: June 14–16, 1961
Objective: To better acquaint engineers, scientists and college faculty with new techniques and theories in relation to the various gases
For: Engineers, scientists, college faculty
Address: Dr. C. Fred Gurnham, Prof. and Head, Chemical Engineering, 414 Olds Hall, Michigan State University, East Lansing, Michigan

International Symposium on Microchemical Techniques

Date: August 12–19, 1961
Objective: To present new material and the interchange of technical information on instrumentation and new techniques of microchemistry
For: All persons interested in microchemical techniques
Fee: $15.00
Address: Conference Center, The Pennsylvania State University, University Park, Pa.

Logic, Switching Systems, and Automata

Date: June 5–16, 1961 (tentative)
Objective: Coordinated presentation of modern development in the area of topic
For: Any technically qualified person, whether from education or industry
Fee: $250.00, except that educators are entitled to a special $125.00 institutional rate on request
Address: Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia 4, Pennsylvania

Materials, Summer Institute on Properties of

Date: July 13–August 23, 1961
Objective: Classroom and laboratory work at the graduate level in modern science of engineering materials
For: College and university teachers of engineering
Limitations: Total number–40
Fee: National Science Foundation pays each participant $450.00 plus travel allowances plus dependents' allowances
Address: Dr. Glenn Murphy, 213 Marston Hall, Iowa State University, Ames, Iowa

Mathematics and Engineering Sciences for Engineering Professors, NSF Summer Institute

Date: June 6–August 5, 1960
Objective: To train engineering teachers in programming and problem solving on digital computers
Limitations: Participants must be college teachers of engineering in a recognized engineering school in the U. S. or its possessions with a minimum of two years' college teaching in engineering subjects and must not have passed 45th birthday
Fee: $675.00 for nine weeks
Address: Dr. M. A. Nobles, Professor and Head, Dept. of Petroleum & Geological Engineering, Louisiana Polytechnic Institute, Ruston, Louisiana

Mechanics of the Solid State

Date: June 11–23, 1961
Objective: To provide a broad, up-to-date knowledge of material behavior in machines, structures, and other engineering devices
For: Research engineers, designers, and materials scientists and engineers
Fee: $175.00
Address: Engineering Seminars, Conference Center, The Pennsylvania State University, University Park, Pa.

Midwest Conference of Fluid and Solid Mechanics

Date: September 6–8, 1961
Objective: Presentation of new research and development work done in the fields of fluid and solid mechanics; to enable universities and industries to keep abreast of new research
For: Engineers from both colleges and industries. These people will be scientifically inclined
Fee: $15.00
Address: Dr. Joachim E. Lay, 14 Olds Hall, Michigan State University, East Lansing, Michigan

Missouri Valley Regional Foundry Conference

Date: September 21–22, 1961 (Biennually)
Objective: Presentation of current foundry technology
For: Management, engineers, educators
Fee: $15.00 Registration (Does not include housing)
Address: Mo. Valley Reg. Foundry Conf., c/o Dept. of Met. Engr., Missouri School of Mines & Met., Rolla, Missouri

Modern Radar Techniques

Date: June 19–30, 1961
Objective: Coordinated presentation of modern developments in the area of topic
For: Any technically qualified person, whether from education or industry
Fee: $250.00, except that educators are entitled to a special $125.00 institutional rate on request
Address: Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia 4, Pennsylvania

National Science Foundation Course

Date: June 12–August 19, 1961
Objective: Advancement of knowledge and improvement of teaching methods in engineering

For: College teachers
Limitations: At least a Bachelor's Degree from an accredited school in engineering, science or mathematics, engaged in teaching at the collegiate level. Show need for the Institute
Fee: A stipend of $750.00 will be granted to each participant with additional grants of $140.00 per dependent (max. 4)
Address: Professor M. Bottaccini, Department of Mechanical Engineering, The University of Arizona, Tucson, Arizona

New Devices for Amplification and Switching

Date: June 5–16, 1961 (tentative)
Objective: Coordinated presentation of modern development in the area of topic
For: Any technically qualified person, whether from education or industry
Fee: $250.00, except that educators are entitled to a special $125.00 institutional rate on request
Address: Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia 4, Pennsylvania

Nuclear Reactor Theory for Engineering Faculty

Date: June 18–August 11, 1961
Objective: To present topics at a sufficiently high level that the attendees will be able to organize and present a reactor theory course based on one of the advanced textbooks in that field
For: Full-time staff members from institutions engaged in or developing nuclear programs and who have an understanding of introductory reactor theory at the level presented in previous basic ASEE–AEC summer institutes
Fee: Funded by the Atomic Energy Commission
Address: Nuclear Engineering Department, 231 Sackett Building, The Pennsylvania State University, University Park, Pa.

Operations Research: Inventory and Production Control

Date: June 19–July 7, 1961; once only
Objective: Application of operations research theory and techniques to problems of inventory and production control
For: Educators; engineers in science and industry
Fee: $500.00; no stipend
Address: Engineering and Sciences Extension, University of California, Berkeley 4, California

Paint Short Course for Beginners

Date: June 5–16, 1961 (Annually)
Objective: To acquaint anyone with the chemistry and technology of coatings
For: Any interested party
Limitations: 30 students
Fee: $50.00 registration
Address: Dr. Wouter Bosch. Dept. of Chem. Eng. & Chem. M.S.M., Rolla, Mo.

Paint Short Course for High School Chemistry Teachers

Date: 20–27 June, 1961 (Annually)
Objective: To familiarize high school chemistry teachers with the chemistry and technology of coatings
For: High school chemistry teachers
Limitations: Teachers selected by the Federation of Societies for Paint Technology
Address: Dr. Wouter Bosch, Depart. of Chem. Eng. & Chem., M.S.M., Rolla, Mo.

Petroleum Reservoir Engineering

Date: June 5–16, 1961 (Frequency-annually)
Objective: Review of principles and practice of petroleum reservoir engineering
For: Practicing petroleum engineers or teachers of the subject. Also geologist and geological engineers
Fee: $225.00 per person, excluding room and board
Address: Petroleum Engineering Department, Attention Dr. Wieland, The University of Tulsa, Tulsa 4, Oklahoma

Planning Aspects of Atomic Shelter

Date: July 9–21, 1961
Objective: Planning and preliminary design aspects of buildings, shelters, and facilities to resist the effects of nuclear weapons
For: Architects and engineers (background or experience in nuclear engineering *not* required)
Fee: $250.00
Address: Engineering Seminars, Conference Center, The Pennsylvania State University, University Park, Pa.

Plasma Physics and Magnetogasdynamics

Date: August 23–25, 1961
Objective: Plasma physics and magnetogasdynamics

For: University faculties and scientists, industry and national laboratories
Fee: Nominal
Address: Gas Dynamics Laboratory, Northwestern University, Evanston, Ill.

Plastic Tooling Conference

Date: June 15, 1961
Address: Head, Conference Department, Memorial Center, Purdue University

Polymer Chemistry Conference and Advanced Paint Refresher Seminar

Date: July 17–28, 1961 (Annually)
Objective: To acquaint students with the organic and physical chemistry of polymers, as used in the paint, fiber, plastics and rubber industries
For: Chemists with some experience
Limitations: 60 students
Fee: $40.00
Address: Dr. Wouter Bosch, Dept. of Chem. Eng. & Chem., M.S.M., Rolla, Mo.

Process Dynamics and Control Workshop

Date: June 19–30, 1961
Objective: Introduction to chemical process dynamics, control and optimization
For: Chemical, control, and systems engineers
Fee: $250.00; Faculty $125.00
Address: Dr. C. J. Huang, University of Houston, Houston 4, Texas

Quality Control by Statistical Methods

Date: Jan. 29, 1962 thru Feb. 8, 1962
Objective: Provide education and training in use of statistical techniques in industrial quality control
For: Quality control managers, industrial management, educators, etc.
Fee: $125.00 per person—covers books, supplies and registration fees
Address: University of Illinois, Dept. of Mech. and Ind. Engr., Urbana, Ill.

R & D Management Development

Date: June 25–30, 1961
Objective: To develop management skills for engineers and scientists in supervision
For: Engineers, scientists, mathematicians, and others in a position of leadership in research and development organizations
Fee: $95.00
Address: Engineering Seminars, Conference Center, The Pennsylvania State University, University Park, Pa.

Reactor Experimentation, AEC–ASEE Sponsored Summer Institute

Date: August 21–September 15, 1961 (tentative)
Objective: For engineering or science faculty who will have responsibility for planning or conducting research built around a nuclear reactor
For: Applicants solicited by the AEC and selected by a committee of ASEE
Limitations: Participants selected about February 16, 1961
Fee: Fees paid by the AEC
Address: J. W. Seyler, Asst. Secretary, ASEE, University of Illinois, Urbana, Ill.

Refresher Course for Engineers

Date: Starting January 9, 1962—Annually
Objective: Review of statics, strength of materials, thermodynamics, fluid mechanics, and dynamics
For: Review to prepare engineers to take examination for professional engineering registration
Limitations: Area
Fee: $26 for 12 meetings of 2½ hours
Address: Field Services Division, Western Michigan University, Kalamazoo, Michigan

Short Course on Design of Experiments

Date: June 6–16, 1961
Address: Head, Conference Department, Memorial Center, Purdue University

Short Course on Operations Research Methods

Date: June 6–16, 1961
Address: Head, Conference Department, Memorial Center, Purdue University

Space Technology (Rockets), Summer Institute

Date: June 26–August 5, 1961
Objective: To supply to the engineering colleges of the nation, staff members, now deficient in numbers, who are informed in depth and detail on a specialty which is vital to national survival and which has developed only within the last decade
Limitations: 40 participants will be selected. Must have B.S. degree, equivalent of two years full-time college level teaching by July 1961. Math through ordinary diff. equatns
Fee: No tuition
Address: Mr. Lyman Nickel, Dept. of Aero Engineering, Stanford, California

Structural Aspects of Architectural Engineering

Date: September 10–15, 1961
Objective: To present up-to-date information on the analysis and design of structural systems
For: Engineers and architects involved in detailed design of structural systems of buildings
Fee: $100.00
Address: Engineering Seminars, Conference Center, The Pennsylvania State University, University Park, Pa.

Structural Engineering Aspects of Atomic Shelter

Date: July 23–August 4, 1961
Objective: Principles of analysis and design of structural systems and radiation shielding systems of buildings, shelters, and facilities to resist the effects of nuclear weapons
For: Structural and architectural engineers (background or experience in nuclear engineering *not* required)
Fee: $250.00
Address: Engineering Seminars, Conference Center, The Pennsylvania State University, University Park, Pa.

Summer Fluid Mechancis Institute

Date: June 19–Aug. 11, 1961
For: College teachers of fluid mechanics
Limitations: 40 teachers—applications must be in by Feb. 15
Address: Colorado State Univ., Fort Collins, Colorado

Summer Institute

Date: July 17–August 25, 1961
For: Teachers of basic engineering subjects
Fee: Stipend 450.00 plus travel paid by NSF
Address: College of Engineering, University of Arkansas

Summer Institute in Engineering for College Teachers of Engineering—NSF

Date: July 10 through August 18, 1961
Objective: Transport phenomena—matrix tensor methods—thermodynamics—science of materials
For: Engineering educators
Limitations: Nation wide
Address: Prof. R. H. Seavy, Stevens Institute of Technology, Hoboken, New Jersey

Summer Institute on Effective Teaching for Engineering Teachers

Date: August 27–September 9, 1961
Objective: To study and practice successful teaching procedures as applied to engineering subjects
For: Young engineering teachers with one to three years teaching experience and for mature engineering teachers with over 10 years' experience
Address: Otis E. Lancaster, George Westinghouse Professor of Engineering Education, 101 Hammond Building, The Pennsylvania State University, University Park, Pa.

Theoretical Aspects of Magnetohydrodynamics

Date: August 13–18, 1961
Objective: A study of the fundamental magnetohydrodynamic equations and their applications to wave phenomena, boundary layer phenomena, hydrodynamic instabilities, and plasma propulsion
For: Engineers, physicists, and research scientists interested in the theoretical aspects of the fluid dynamics of gaseous plasma
Fee: $100.00
Address: Engineering Seminars, Conference Center, The Pennsylvania State University, University Park, Pa.

Titanium Metallurgy Conference, 7th Annual Meeting

Date: September 11–12, 1961
Objective: Convey information on current research and progress in the technology of titanium
For: Anyone interested
Fee: $20.00
Address: M. Berk, New York University, College of Engineering, New York 53, N. Y.

Tool Engineer's Seminar

Date: November 1961 (exact date to be determined)
Objective: To bring participation up to date on recent developments
For: Engineers, managements, educators
Fee: $10.00 (includes 2 days technical sessions and banquet)
Address: Engineering Extension Service, Box 245, State College, Mississippi

Underwater Acoustics

Date: June 18–23, 1961
Objective: To furnish an understanding of the problems of underwater sound gen-

eration, transmission, and detection and the design of transducers

For: Engineers and scientists concerned with research, development, and engineering in the field of underwater acoustics

Fee: $100.00

Address: Engineering Seminars, Conference Center, The Pennsylvania State University, University Park, Pa.

Underwater Missile Engineering

Date: June 18–30, 1961

Objective: A classified seminar on the principles underlying the design synthesis of underwater guided missiles

For: Engineers, scientists, naval officers, and administrators associated with underwater missile research and development

Limitations: Attendance subject to security approval by the Navy

Fee: $175.00

Address: Engineering Seminars, Conference Center, The Pennsylvania State University, University Park, Pa.

Western Electronic Show and Convention

Date: August 22–25, 1961

Address: The Cow Palace, San Francisco, California

Work Measurement

Date: September 17–22, 1961

Objective: To show how modern industrial engineering techniques—work sampling, queuing theory, statistical inference, computer simulation—may be applied to day-to-day manufacturing operations

For: Industrial engineers and industrial engineering department heads

Fee: $100.00

Address: Engineering Seminars, Conference Center, The Pennsylvania State University, University Park, Pa.

What's Going on in ASEE

(*Continued from page 753*)

The visiting engineer program for junior colleges and small liberal arts colleges is progressing slowly, but is being well received. The visitors, as a rule, get a real workout. And a sufficient number of unsolicited letters of appreciation are being received to indicate the plan should be continued.

There also was much discussion about a study of graduate work in engineering. Between the off-campus problem, the accrediting problems of ECPD, the general concept of criteria, and the place of engineering design, there certainly is room for much work. There is the danger of other groups stepping in and doing something if ASEE doesn't soon "get on the ball."

The establishment of a National Academy of Engineers also was considered. The big question is whether it should be separate from the Academy of Sciences or whether the Engineering Division now in NAS should be strengthened to put it on a par with the scientists. No preference was indicated, but the Executive Board voted to push hard for immediate accomplishment of one or the other.

The Executive Board voted to reaffirm ASEE's previous stand against federal undergraduate scholarships and in favor of generous support of federal graduate fellowships. The American Council on Education requested its member societies to take a stand, because it has endorsed undergraduate scholarships and wished to be able to present a united front.

The next meeting of the Executive Board was in Chicago, Illinois, on April 7, 1961.

Mechanics Division Bulletin

Executive Committee

J. O. Smith, Ch.....1961	E. J. Marmo.....1962	D. C. Drucker.....1963
D. R. Carver.....1961	E. P. Popov.....1962	E. C. Clark.....1964
H. R. Lissner *.....1961	F. P. Beer.....1963	I. H. Shames.....1964

Secretary of the Mechanics Division: Lt. John A. Weese, Department of Mechanics, U. S. Air Force Academy, Colorado.

Editor: Arthur W. Davis, Department of Theoretical and Applied Mechanics, Iowa State University, Ames, Iowa.

Mechanics Division Program, University of Kentucky, Lexington

Monday, June 26

10:00 a.m. Conference

Theme: Mechanics Teaching in Europe
Presiding: E. P. Popov, University of California, Berkeley

Panel:

1. In England. J. E. Adkins, Brown University
2. In France and Switzerland. F. P. Beer, Lehigh University
3. In Germany. G. Mesmer, Washington University
4. In Italy. E. Volterra, University of Texas

6:00 p.m. Dinners

Executive Committee
Presiding: J. O. Smith, University of Illinois

Tuesday, June 27

12:00 Noon Luncheon

Business Meeting
Presiding: J. O. Smith, University of Illinois

2:00 p.m. Conference

Theme: The Role of Vector Analysis in Mechanics
Presiding: W. T. Thomson, University of California, Los Angeles

Panel:

1. Archie Higdon, U. S. Air Force Academy
2. T. R. Kane, University of Pennsylvania
3. J. L. Meriam, University of California, Berkeley
4. F. L. Singer, New York University

Wednesday, June 28

12:00 Noon Luncheon

Joint Luncheon, Engineering Economy Division

2:00 p.m. Conference

Joint Conference with several divisions, discussing the theme "The Birth of A Book."

* Division Representative on the General Council.

New Directions in Engineering Mechanics

HENRY F. HRUBECKY

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Department of Engineering Mechanics,
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It is apparent to anyone in engineering education that the curriculum in recent years has undergone and is undergoing significant changes. Established notions of course content transmitted decade after decade from master to disciple are in question. More than a patch-quilt addition of courses, the rapid rate of scientific and engineering achievement has resulted in a complete re-evaluation of the philosophy and scope of the undergraduate program.

One's view of the engineer as being part scientist, part artist, remains unchanged, but the degree of emphasis of these parts and their mutual chronological development has changed. The basic purpose of one philosophy was to develop both of these parts into some harmonious whole, in which the matriculated student possessed some insight into the art and science of his profession. Time and new knowledge has brought about a reappraisal by engineering educators and industrial management. Time and new knowledge has shifted the responsibility for the scientific development of the engineer on the university, the art in its increasing complexity and the teaching of it on industry.

The consequent state of flux arising in this era of transition, let alone being unavoidable, is a healthy one. Motivated by the desire to improve the traditional subject matter format, the engineering educator has focused close scrutiny on his subject matter, in a new light selecting what is of fundamental significance and what is supporting or secondary. Recent years have indicated an ever-increasing percentage of students entering graduate school. For those failing to do so this has become tantamount to self education in the advanced phases of the technology. Thus, inevitably the engineering educator must direct his efforts to the development of knowledge and their tools of analysis in a generalized perspective and presentation to best foster this future study.

This transition is no less true than in the basic undergraduate engineering mechanics curriculum which has had the time-honored division of its courses into statics, strength of materials, fluid mechancis, and dynamics. The emphasis of application, though not restricted to, has been principally directed towards the interests of the civil engineer (hydraulics, structures) in the first three mentioned courses and towards those of the mechanical engineer (linkage mechanisms) in the last-mentioned. If it be agreed that mechanics is that branch of engineering that is concerned with the behavior of matter and its displacement and deformation under time-dependent or independent forces, then it is a study pertinent to all engineering disciplines without being specifically directed to any one. It is in this position, independent of the needs or dictates of any one professional discipline, that the direction of mechanics must logically develop. This is no less true at the undergraduate level than it has been at the graduate level.

Concomitant with this transition in engineering mechanics has been the ever-increasing utilization of vector methods in the undergraduate courses. Of course, this approach is not new. In the past this tool of analysis was a matter of personal predilection; the present trend has whole departments now employing or contemplating employment of vector methods. The primary but far more subtle and difficult aspect of the professor's task is to develop within the student the capability of analyzing in some systematic manner the behavior of a physical system in light of applicable principles. This facet of the student's de-

Presented at the meeting of the American Society for Engineering Education, Southeastern Section, Columbia, South Carolina, April 1960.

velopment is still of basic importance. The nature of the mathematics used in describing the mathematical model of the physical system exists only in a supporting role. The justification for the employment of vector operations exists if affirmative answers to the following questions can be given: 1. Does their use clarify the basic definitions, concepts, and analysis? 2. Is their use consistent with the mathematical maturity of the student?

In the past all texts in engineering mechanics introduced the student to some concept of a vector. In texts employing a scalar presentation, more often than not an incomplete version of the concept is given. The student fails to see the vector as a quantity subject to certain defined laws and operations and possessing properties analogous to the familiar scalar quantity. Nor is the fact made clear that these laws, properties, and operations concur with the mathematical model formulated of his physical system. Beyond the laws and operations governing vector addition, the logical question whether other laws and operations exist may occur to only a few inquiring minds. Thus a powerful tool of analysis is shorn of its effectiveness at a stage where its simple and logical development would have contributed to better conceptual understanding.

Clearly the concepts in statics are fewer than in dynamics, for example. The laws and operations governing vector addition and multiplication are needed, and are not incompatible with the student's background. Here vector employment lends clarity to and differentiates between such concepts as the moment of a force with respect to a point and with respect to a line. A further illustration: the analysis of the "wrench" resultant of a general force-couple space system is simplified. In dynamics the instructor is immediately faced with the differentiation of the position vector. I believe most instructors will agree that it is in accurate concepts of linear and angular velocity and acceleration and their representation in various coordinate systems that students have considerable difficulty. Hazy notions of these continuously plague them in their study of kinetics. Misconceptions arise, such as, for example, the representation of a finite rotation as a vector, which often leads to faulty views involving the motion of lines.

Summarizing personal experiences and those of fellow colleagues some of the disadvantages and advantages involved in the utilization of vector methods in statics and dynamics will now be considered.

In problem exercises involving two-dimensional behavior, the formulation of the problem in vector form may often be more laborious than the actual analysis involved, e.g., in multi-membered structural systems. In addition, often because of previous unfamiliarity with vector algebra and calculus, the student may become so concerned with the vector operation involved that he loses sight of the basic analysis. Thus it is advisable to stress vector methods consistently throughout a course in statics rather than postpone their use to a later period when the concepts become increasingly difficult.

The major advantage of vector methods is the clarity, accuracy, and succinctness they lend to the definitions and concepts of mechanics. In addition, they appeal to and are consistent with the visual-geometric perspective of engineers. Furthermore, in space analysis two-dimensional views extrapolated to three-dimensional behavior often may lead to erroneous conclusions, especially in rigid-body dynamics. Contrary to what might be expected, the relatively short time needed to present the vector fundamentals allows for greater course coverage. In view of this, time can be found to properly balance the present, by some, repetitious problem drill conduction of courses with such additional topics rarely covered as, states of equilibrium, energy methods, statically indeterminate systems in statics; and in dynamics, variable mass systems and three-dimensional particle and rigid body systems, to cite a few.

It may be seen from a simple cursory examination of current literature in engineering that the need for an understanding of vector methods is necessary on the part of the student for any future advanced study, be it on a formal or an informal basis.

An Experiment in Teaching Newton's Laws of Motion

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DILLARD JACOBS

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We suppose most undergraduate engineering departments have a course designed to orient the student and to confront him with the serious business of an engineering course of study. The course we have developed in the Mechanical Engineering Department at Vanderbilt to help the student "grow up" is Kinematics of Machinery, a 1-year, 6-hour-per-week laboratory course given to sophomores. It serves as the initial contact between the student and the department he has chosen to enter.

As it is taught, it is the first course he has in college that causes him to change his primary attention from the mastery of facts to the analysis of physical problems. Finally, by using one of the excellent new texts on the subject, which are far broader and more analytical than those available a decade ago, the student is introduced at the beginning to a fundamental study of much of the basis of mechanical engineering.

We have required 2 co-requisites: Introductory Physics as well as Integral Calculus and Differential Equations. These, and the corollary courses in statics and strength of materials, furnish the students other contacts with theory. Much use is made of newly learned mathematics as the Kinematics of Machinery course progresses. As seen from the title of this article, part of the course is devoted to driving home, by experiment and analysis, an important application of Newton's Laws of Motion.

The experiment is presented about mid-year and consists of making a rather thorough analysis of the performance of the student's own automobile based on simple velocity-time data.

A "fifth wheel," which consists of a yoke carrying a bicycle wheel coupled to a small direct-current tachometer generator is attached to the car's rear bumper. The voltage output of the generator is recorded on a Brush time–base recorder carried in the car. The students first have the job of calibrating the voltage vs. speed. A test run consists of accelerating the car from a low speed to the legal speed limit and then coasting to about 20 miles per hour on a reasonably level stretch of road. Two runs are made in opposite directions to compensate for road and wind irregularities. Only one more bit of data is required: the mass of the car and occupants.

With his data recorded the student first replots the velocity vs. time data from the recorder chart onto rectangular coordinates and fairs in an average curve. Starting with the coasting data he differentiates this curve graphically to obtain the deceleration and multiplies by the mass to obtain the drag force. Data pertaining to acceleration is manipulated in the same way to obtain the accelerating force component. The results may now be put together to yield curves of drag, accelerating and total horsepower vs. car speed; also force and/or torque vs. speed.

The curve of drag force vs. speed lends itself nicely to a bit of mathematical analysis that is well within the ability of the student and serves to acquaint him with useful techniques. Plotted on logarithmic graph paper these data produce a curve with a sharp knee while the two ends of the curve are asymptotic to straight lines. At low car speed the

drag force is nearly constant while at high speeds the asymptote has a slope of about 1.8 to 2.0. By deducting the apparent low speed drag from the ordinate of the plotted curve and replotting, the curve can be separated into its asymptotes and the equation constants evaluated: $F_d = a + bV^n$

From the practical standpoint the criticism can be made that this method of testing ignores the rotational inertia of engine, gears, and wheels and thus gives values that are too low. This criticism is valid, especially for high performance automobiles, but the discrepancy is explained to the students and serves to whet the imagination of some. A much more valid criticism is that in hilly country and crowded highways real difficulty may be encountered in finding a suitable stretch of road for the test.

Since it was first tried we have found the test to be an excellent coordinated teaching aid. The student learns something about the performance of his own automobile, a machine which he often dearly loves. He must consider the relationship of force to mass and acceleration and of force to reaction. He must not confuse force with work or power. He learns how to take data, refine and manipulate the data, and determine interesting results. He learns useful techniques such as graphical differentiation and integration and the use of logarithmic graph paper for writing empirical equations. The whole experience requires only 2 or 3 weeks in class but, together with other subjects taught in the course, it has an extremely maturing effect on the young student.

This particular problem is presented to the sophomore at a time when he needs and appreciates this coordination of the sciences and arts of engineering. The insight gained in this relatively extensive combination of experiment and application of mathematical thought nearly always gives the student added vigor and sparks his intellectual curiosity in the work that follows. The ability to provide an engineering answer and to be able to extend his knowledge of science in this direction has a profound effect in succeeding class debates about automobile performance.

Since the problem is followed by the conventional study of gears and the broader area of computing elements and systems, it is believed that the role of the new Kinematics need not be questioned but that a more suitable name might be adopted for the course. May we suggest:

Elements of Mechanical Engineering Systems
Mechanical Engineering Operations
The Science and Art of Mechanical Engineering Analysis

In the current reassessments of this field of study it is to be hoped that many of the advantages of the course in teaching and orienting the student—from his viewpoint—will not be overlooked. Certainly he should become familiar with those mechanical devices the human race has spent thousands of years in discovering.

MICHIGAN EXPANDS AT WILLOW RUN

Under an agreement signed Feb. 9, The University of Michigan has acquired 156 acres of land and 37 buildings included in the Willow Run Air Force Station and the Packard Hangar at Willow Run Airport.

The land and buildings, acquired from the federal government, will be available for educational activities of the U-M and will be used soon by the University's Institute of Science and Technology. The agreement provides that the University can acquire full title to the land and buildings provided full use is made of the facilities over a period of 20 years.

The Air Force Station area, occupied until Nov. 1, 1959 by the 30th Air Division, has 133 acres and 31 buildings ranging in size from 15,429 square feet to 16 square feet.

The New Look in Engineering Mechanics Laboratory Course Work at the University of Virginia

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A face lifting operation has been performed on the strength of materials laboratory course at the University of Virginia with the amazing results that students have shown not only interest, but enthusiasm, in their work. This "new look," inaugurated in the fall of 1959, is the result of a radical change in the philosophy of presenting laboratory course material. The decision to make a complete departure from the conventional and often uninspiring type of physical testing exercises was reached after many attempts had been made to stimulate interest in the course work by revising experiments, selecting different specimens, scheduling periodic quizzes, etc. All of these attempts seemed to be ineffective as each succeeding class retained the same indifferent attitude toward their assignments and experiments as previous classes had demonstrated. Because much of the lecture course work taken currently by the students was fast moving, intellectually challenging, and made real demands upon their abilities, the laboratory course in comparison was further relegated to the position of something to be endured if the diploma were to be acquired. Thus, to compete with the pace of the lecture courses and to encourage the students to continue to exercise their minds when in the laboratory, it was decided to replace the routine testing exercises and data sheet "reports" with project assignments which would require individual thought and action on the part of each student. In short, *the strength of materials laboratory course, as now conducted, emphasizes the formulation and design of engineering experiments to provide data which will assist in the solution of fundamental engineering problems.*

With this objective in mind, the technical aspects of conducting physical tests are regarded as a means to an end—that of producing desired data—rather than an end in itself. Thus, a minimum amount of time and instructional effort is devoted to the operation of equipment and the mechanics of performing tests. Instead, the capabilities and applications of the testing equipment and instruments are stressed in an effort to provide the student with definite knowledge of the tools he will have at his disposal to apply to the solution of his problem. Fortunately, the testing laboratory is equipped with a variety of strain and load measuring devices in sufficient quantity that several testing procedures can be devised for attacking a given problem without undue equipment or facility restrictions.

The objectives of the "new look" have been achieved to some degree over the past three semesters by developing imaginative and realistic engineering projects to be solved by each student working initially on his own and then jointly with other students. Considerable effort is taken to devise projects which will arouse the student's curiosity by relating them to topics of current interest or to appealing phases of his professional specialty. Usually, the project problems have no single, clear-cut solution, but may have several equally correct solutions.

One of the more popular projects among the aeronautical engineering students is one requiring the recommendation for the redesign of a support bracket for a guidance instrument mounted on the fuselage of an aircraft. Inspiration

for this project developed from the tragic crash of a commercial airliner a few miles from the University grounds. All of the students were well aware of this calamity as some had assisted in rescue operations. Since the cause of the crash was never determined conclusively, it did not require much persuasion to convince the students that the fatigue failure of a structural member, identical to the one they were investigating, could well have been the reason the pilot failed to make a proper landing approach and struck a mountain miles off his course. The investigations conducted in this particular project emphasized the effects of stress concentration and repeated stress reversals upon aluminum.

Another project which has been conducted enthusiastically by various engineering students is one requiring the investigation of material to support the base plate of a heavy forging machine. To provide an opportunity for deliberation upon alternate schemes of supporting the machine, timber was specified as the material to be investigated. Needless to say, the non-isotropic stress-strain characteristics of wood along with its susceptibility to humidity changes gave the students many variables to consider. A less involved project which has received favorable comment from the civil engineering students is one requiring the investigation of several unknown metallic materials to determine if their physical properties meet certain specification requirements for a stated structural application. The project is so devised that none of the materials meet all of the specification requirements so that the student must weigh the deficiencies of the individual specimen against the performance requirement and present a recommendation as to which material should be used in view of the known service conditions and the intent of the specifications.

The one-semester period devoted to the laboratory course usually enables the students to participate in five projects. An average of two weeks is spent on each project, but if more time is needed for the completion of an individual project, provision is made for a time extension. A "you are on your own" attitude practiced by the instructor encourages the student to set his own pace and to make him feel that he is responsible to himself as well as the instructor. Experience of several semesters has indicated that the majority of the students working under this policy produced more and better work than previous students did who were held to a rigid assignment schedule. To be complete in this observation and to be quite honest, there have been a small number of students who take advantage of the professional approach to the course and produce as little as they can get by with. However, this type of enrollee is invariably present in every class and will perform essentially the same regardless of the system under which he works.

Procedures

Since the project work is the heart of the "new look," the reader will be interested in the procedural aspects of this portion of the course. At the first meeting of the class, the students are advised through instruction sheets that their project work will consist of the following three parts:

1. A literature research and the preparation of a working plan for conducting the laboratory investigations associated with the problem.
2. A compilation of experimental data based upon physical tests performed by the students.
3. An analysis of experimental data and the preparation of an engineering report.

Project assignments are made by providing each student with a statement of the problem along with sketches and pertinent information which relates the topic to a real situation (as in the case of the aircraft bracket problem). The week following a project assignment, the student presents his written plan for the solution to his problem and defends it orally in a group conference with the instructor and several of his classmates who have received the same project as-

signment. The working plan, if it is a good one, will include an outlined procedure for solving the problem with attention given to experimental data required and the equipment and test set-up to provide the data. In addition, the plan will anticipate difficulties which may be encountered in obtaining experimental data or in interpreting the data once obtained. Alternate methods for performing tests are also commented upon with an evaluation of the reliability of the various approaches. The inclusion of detailed descriptions of specimen design, instruments, equipment, and testing procedures required is mandatory because it is from this working plan that the student must go directly into the testing phase of his project. If the student has not done a respectable amount of background reading on the various aspects of his problem, he quite obviously will be embarrassed as he attempts to defend his plan before his classmates. Needless to say, student preparation for the second project conference is much better than it is for the first conference.

The preparation of the working plan is probably the most valuable aspect of the entire project from a learning standpoint. The student must acquire information sometimes quite unrelated to his previous experiences on his own and must then formulate a logical approach to the solution of a problem based on the fundamentals of engineering mechanics and materials. Prior completion of lecture courses in mechanics, materials and mathematics provides an adequate foundation upon which the student can base his thinking. It is in this phase of the project that the student more nearly achieves professional status than in any other. He works entirely on his own initiative and at his own speed. Informal conferences with his instructor may be arranged during this period if desired, but no collaboration with other students is permitted.

Upon the approval of a compromise working plan for the group (three or four students must work together to provide sufficient personnel to perform the experimental testing) specimens and equipment are provided and the tests are performed. If properly organized, some tests may be completed in several hours; others, such as the fatigue investigations, require several weeks of intermittent tests. Though perhaps not as valuable from a creative consideration, the sudden realization that an idea for a test set up which looked good on paper was not at all workable when it had to be provided in a laboratory, gives the student an appreciation of some of the difficulties and practicable aspects of obtaining experimental verification of a theory. Also, it provides him with a better perspective when interpreting and applying experimental results of specific tests to generalized concepts. As an example, one project involving the evaluation of friction and bearing strength of a bolted joint gave the students a terrific amount of trouble trying to attach strain gages to the specimen in such a manner that they would measure only those strains desired or ones which could be accounted for analytically. Poor experimental results in this case convinced the students that it is not always possible to obtain exactly the strain information that is desired, even in a relatively simple experiment such as they were conducting.

The last phase of the project—data analysis and preparation of an engineering report—provides the student with an opportunity to reflect upon the errors or inaccuracies in his original thinking when preparing his proposal and to express his experimental findings and thoughts in a formalized manner just as he will have to do a few years hence as a professional engineer. The requirements for the engineering reports are quite demanding but the student is encouraged to do his very best by exempting him from writing successive formal reports as soon as he submits one of superior quality. This incentive plan has resulted in considerable effort being exerted by some students on their first several reports with the production of some excellent papers. A lengthy report necessarily results if it is complete with a presentation of the theoretical basis for the problem solution, experimental data and laboratory procedures, interpretation of the experimental findings as applied to the problem,

conclusions, and recommendations for other approaches to a solution for the problem. Some of the students have submitted commendable documents—enhanced with photographs of tests and specimens they made themselves—and seem to take more than ordinary pride in their accomplishment. The exemption policy was instituted to accompany the "new look" because it was felt that the opportunity for the students to apply the fundamentals acquired in their technical English course to a real situation should not go unheeded. Further, it was felt that once the student had demonstrated his ability to submit a creditable report, it was a misuse of his time to require that he continue to write lengthy and formalized reports. Since the data analysis and report composition is entirely the work of the individual, the student who exerts himself to a greater extent on the first several reports performs less routine work than the less industrious student who never achieves an exemption status.

To provide a breathing space between projects, a demonstration laboratory is arranged in which data are developed to verify the theories associated with buckling, strain hardening and relaxation of metals, combined stresses, etc. which are not covered in project assignments. These sessions require prior study by the student on subjects to be covered and a one-hour quiz is given to the class the following period on the theory and experimental results obtained. No reports are required of the students for the demonstration laboratory sessions.

A final examination is given in the course which is designed for a full three-hour period. Needless to say, with such an approach taken to the course work during the semester, the instructor may let his imagination run wild in the preparation of the examination. Such was the case during the past year when the instructor gave a single problem which required the preparation of a working plan for a testing procedure to develop experimental data on a new reinforced plastic material for which the required data had never been obtained by anyone previously. An examination of this nature permitted complete freedom on the part of the students to refer to any literature they could obtain within the library or other sources, though they were advised that they would have to rely primarily on fundamental testing principles proven successful in tests with other types of materials. On several occasions, oral examinations have been given in conjunction with a written examination. The oral examination is desirable from the standpoint of obtaining a better evaluation of the student's ability to reason and to think clearly, but has the disadvantage of extending over a period of six to eight hours if the class is fairly large. Therefore, it has been necessary to limit the oral examination technique to class sections of no more than seven or eight students.

This plan of presenting the laboratory course work is obviously limited to small class sections. The facilities at the University of Virginia permit work to proceed on three or four projects simultaneously, so classes consisting of groups of three or four students each may be handled without difficulty. Thus, a total of twelve students is considered the maximum desirable class size.

The astute reader might observe that the "new look" described herein is nothing more than a sugar coated version of the "current look" maintained by many of the engineering schools today. To a certain extent, he would be correct, because the materials investigated, the theories validated, and the equipment utilized are essentially the same regardless of the viewpoint. However, if swallowing the pill leaves a sweet taste instead of a bitter taste in the mouth of the student, there is no doubt that his educational experience has been more pleasant, and of greater importance, more effective. Also, the reader who has not had personal experience with the project method of teaching may observe that the "new look" necessitates a considerable increase in the work load of the instructor and the student. Admittedly, some of the students work harder than they normally would in a conventional laboratory testing course because they *want* to work harder. Strangely enough, there are few complaints from those students

who make the extra effort because they don't seem to mind working on a problem of real interest to them. The complaints come from those who try to accomplish as *little* as possible. There is indeed some increase in the time that the instructor must spend in devising and organizing the projects when compared with the time spent in the conventional type course. Also, the group conferences and the informal consultations held with students between class meetings is time consuming. The heavier task of reading and grading lengthy reports may be relieved by an assistant and by encouraging the students to take advantage of the incentive plan mentioned previously.

It is the opinion of the writer that the instructor is more than compensated for his additional effort by working with students who show enthusiasm, curiosity, and interest in their work to the point of accomplishing more than is required or even expected of them. The privilege of working with intellectually quick students who have been stimulated to a degree by the instructor is rewarding in a way that can be understood and appreciated only by a truly devoted teacher. Indeed, this is teaching at its best.

AFTER–COLLEGE PROFESSIONAL DEVELOPMENT

Engineers are costly for society to produce. They are expensive to maintain. Their output is important to our continued growth, to our high standard of living and in these times particularly to the safety of our country. It is most important that this valuable resource be used to its maximum.

The process by which a young engineer is effectively fitted to a job can be a short one or a long one but in any case it involves three steps: first, finding the job; second, learning the job and; third, growing in the job.

Finding the right job needs attention. Because of the rapid development of science the problems of adapting a particular capability to a particular task of which are changing rapidly is formidable. Learning the job after one gets it may be routine but keeping up is not. Someone has said that the half life of an engineer's education is 15 years. If this is true the technical deterioration of a man's education is at the rate of 3% a year. If we are not to lose this technical capability a constant effort must be made to keep our people abreast of the times and also working on those jobs for which they continue to be best fitted. This effort must not be left to chance nor made exclusively dependent on good motivations or the judgment of our young engineers, but it must also be purposely planned and purposely fostered by responsible executives in industry, professional organizations and colleges.

The ECPD's Committee for the Development of Young Engineers has addressed itself to these purposes. The building blocks of the plan are: (1) Career Orientation; (2) Continuing Education; (3) Professional Identification; (4) Responsible Citizenship; (5) Selected Reading; (6) Personal Appraisal.

The means of implementation are through community action, through action of the professional societies, through industry and its training and professional development programs, and through schools, particularly those concerned with night classes and graduate activity.

Specifically, we feel that a wide distribution of literature which ECPD has prepared and discussions of the points brought up in this literature can go far to doing the job. Information on ECPD's publications can be obtained by writing to:

Engineers' Council for Professional Development
29 West 39th Street
New York 18, New York

JOHN GAMMELL, *Chairman*
Committee on Development of
Young Engineers
Engineers' Council for Professional
Development

INTERNATIONAL STUDIES PROGRAM

The University of Wisconsin's College of Engineering and the Mexican Institute of Technological and Advanced Studies at Monterrey, Mexico will cooperate in a unique program for the training and education of American engineering students at the Mexican institution during the next two years.

The program, first of its kind in the history of United States-Mexican higher education, was made possible with acceptance of a $100,000 grant by the UW Board of Regents from the Carnegie Corporation of New York. The funds will support a junior year program for UW engineering students at the Instituto Tecnologico y de Estudios Superiores de Monterrey, Mexico.

The program is a pioneering undertaking in the field of student exchange with foreign universities in a professional area. Its first year is planned as a pilot study involving only UW engineering students. It may be extended to other American universities later.

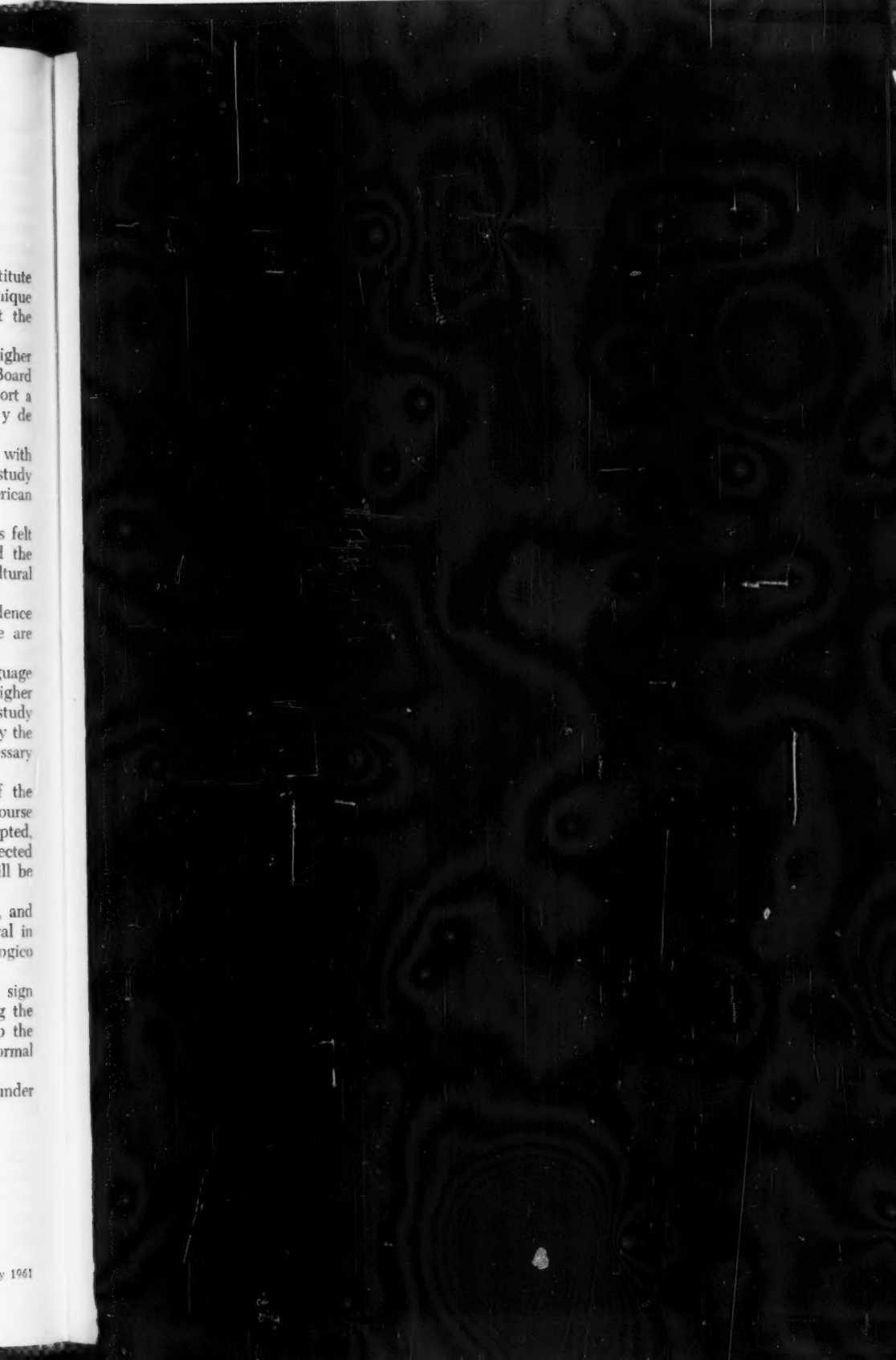
Because of the modern significance of technology in international affairs, it is felt that the program can be important both from a technological standpoint and the standpoint of greater improvement in international relations. Abroad cultural training of the UW engineers is an added important benefit.

Besides the College of Engineering, the University Extension's correspondence study department and the University's department of Spanish and Portuguese are cooperating in the program.

Under the program, eight UW engineering students, after special Spanish language and cultural training, will spend their junior year at the Mexican institution of higher learning. The selected students will be required to enroll in a special home study program in Spanish in UW Extension. Expenses for this part will be covered by the grant for the program, and successful completion of the course will be a necessary condition for continuing in the program.

Selection of students for the intensive language and orientation phase of the program during the summer would be made after reports on the home study course have been received. The students selected would be notified, and if they accepted, would be expected to enroll in a special summer program limited to the selected students. All fees, room, board, and incidental expenses during the session will be paid by the program.

Students who have been selected for the year at Monterrey will be notified, and travel costs will be granted up to a maximum of $200 roundtrip. Upon arrival in Monterrey, Mexico, the students will be under supervision of the Instituto Tecnologico y de Estudios Superiores de Monterrey.

Students who accept a scholarship and become a part of the program must sign an agreement, co-signed by a parent, that they will not leave Monterrey during the academic year except under supervision of the Instituto and will not return to the U. S. until all examinations and academic requirements have been fulfilled and formal dismissal given by the Instituto.

The program will operate throught the UW Engineering Experiment Station under administration of Associate Dean W. R. Marshall, Jr.